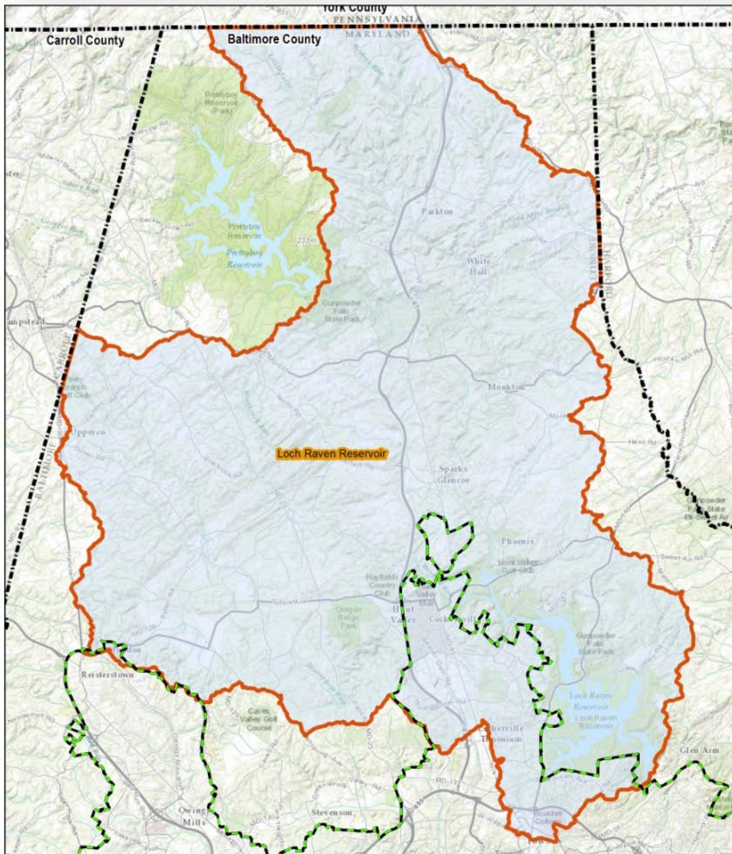
BALTIMORE COUNTY
TMDL IMPLEMENTATION PLAN

Sediment in Loch Raven Reservoir



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List of Abbreviations

ARA	**Antibiotic Resistance Analysis**
BMP	**Best Management Practice**
BOD	**Biological Oxygen Demand**
BSID	**Biological Stressor Identification**
BST	**Bacteria Source Tracking**
CBP	**Chesapeake Bay Program**
CFR	**Code of Federal Regulations**
Chl a	**Chlorophyll a**
COMAR	**Code of Maryland Regulations**
CWA	**Clean Water Act**
DO	**Dissolved Oxygen**
DPW	**Department of Public Works**
ED	**Extended Detention**
EOF	**Edge of Field**
EOS	**Edge of Stream**
EPA	**U.S. Environmental Protection Agency**
EPS	**Environmental Protection & Sustainability**
FSA	**Farm Service Administration**
HSG	**Hydrologic Soil Groups**
HUC	**Hydrologic Unit Code**
IP	**Implementation Plan**
LA	**Load Allocation**
lbs/yr	**Pounds per Year**
MAST	**Maryland Assessment Scenario Tool**
MD	**Maryland**
MDA	**Maryland Department of Agriculture**
MDE	**Maryland Department of Environment**
MDP	**Maryland Department of Planning**
µg/l	**Micrograms per Liter**
mg/l	**Milligrams per Liter**

MGD	**Million Gallons per Day**
MGS	**Maryland Geological Survey**
MOS	**Margin of Safety**
MPN	**Most Probable Number**
MPR	**Maximum Practicable Reduction**
MS4	**Municipal Separate Storm Sewer System**
NLCD	**National Land Cover Dataset**
NMP	**Nutrient Management Plan**
NOAA	**National Oceanic and Atmospheric Administration**
NPDES	**National Pollutant Discharge Elimination System**
NPS	**Nonpoint Source**
NSA	**Neighborhood Source Assessment**
OIT	**Office of Information Technology**
PAA	**Pervious Area Assessment**
PAI	**Office of Permits Approvals & Inspections**
POM	**Particulate Organic Matter**
PS	**Point Source**
RTG	**Reservoir Technical Group**
SCWQP	**Soil Conservation and Water Quality Plan**
SSA	**Science Services Administration**
SSO	**Sanitary Sewer Overflow**
SWAP	**Small Watershed Action Plan**
SWM	**Stormwater Management**
TMDL	**Total Maximum Daily Load**
TN	**Total Nitrogen**
TP	**Total Phosphorus**
TSI	**Trophic State Index**
TSS	**Total Suspended Solids**
URDL	**Urban Rural Demarcation Line**
USGS	**United States Geological Survey**
USLE	**Urban Soil Loss Equation**
WAG	**Watershed Advisory Group**
WIP	**Watershed Implementation Plan**

WLA	**Waste Load Allocation**
WQBEL	**Water Quality Based Effluent Limitations**
WQIA	**Water Quality Improvement Act**
WQLS	**Water Quality Limited Segment**
WQMP	**Water Quality Management Plan**
WRAS	**Watershed Restoration Action Strategy**
WWTP	**Waste Water Treatment Plant**

This Total Maximum Daily Load (TMDL) Implementation Plan, which will henceforth be referred to as IP, has been prepared to address the rate of infilling of Loch Raven Reservoir with sediment, which is negatively affects the longevity of the drinking water supply for the Baltimore metropolitan region. Specifically, the amount of sediment that needs to be reduced has been established as a TMDL by Maryland Department of the Environment (MDE) and titled *Total Maximum Daily Load of Phosphorus and Sediments for Loch Raven Reservoir and Total Maximum Daily Load of Phosphorus for Prettyboy Reservoir, Baltimore, Carroll and Harford Counties, Maryland*. After a public comment period, the TMDL was submitted to US Environmental Protection Agency (EPA) for review; EPA approved the TMDL March 27, 2007.

1.1 What is a TMDL?

A TMDL has two different meanings. It is the document that is produced by MDE when any Maryland water body is listed on the state's 303(d) list of impaired and threatened waters. MDE must then submit the TMDL to EPA for approval. Any time a TMDL document is developed, extensive scientific study is done on the pollutant of concern in the listed water body. This study is done with the goal of finding the maximum load of the pollutant that the water body can receive and still meet Maryland's water quality standards. It is often thought of as a "pollution diet" for the watershed. All of the studying and monitoring that is done in preparing the TMDL document boils down to a single maximum load number that will be the target for pollution reduction in the water body. This number is also called a TMDL. In other words, the goal of the TMDL document is to justify the TMDL number, which can be found within the TMDL document.

The TMDL number is expressed as a sum of all the different sources of the pollutant plus a margin of safety (MOS) that accounts for any lack of knowledge or understanding concerning the relationship between loads and water quality and also for any rounding errors in the TMDL calculation. Expressing the TMDL in terms of this simple equation makes it easier to see where pollution reduction efforts need to be focused. In other words, which sources can be reduced to reach the final TMDL number, by how much do they need to be reduced, and which sources are not practical for reduction. The sources that make up the final TMDL number are categorized as either Load Allocation (LA) or Waste Load Allocation (WLA). LAs are all non-point source loads, meaning that they do not come from a single source or pipe. LAs include agricultural runoff, forest runoff, and upstream loads. WLAs are all point source loads, meaning that they do come from a single traceable source. WLAs are further categorized as process water or stormwater. Process water WLA comes from sources that have permits allowing them to release a specific amount of a pollutant into the water. They include individual industrial facilities, individual municipal facilities, and mineral mining facilities. Stormwater WLA is any stormwater that is regulated by a municipal separate storm sewer systems permit (MS4), water from industrial facilities permitted to release stormwater, and all runoff from construction sites. All Baltimore County urban stormwater is regulated under Baltimore County's MS4 permit. That means that stormwater WLA includes all of the water that runs to any storm drain within the watershed area. The MOS is the final part of the equation. The MOS can be implicit, meaning that the final TMDL was calculated in such a way that it accounted for any errors without needing to tack an explicit MOS to the end of the sum of load sources equation. When an explicit MOS is necessary, it is assumed that a 5% reduction of the final TMDL number will be sufficient.

The TMDL number is expressed as a sum of all the different sources of the pollutant plus a margin of safety (MOS). The MOS value helps to account for any lack of knowledge or understanding concerning the relationship between loads and water quality and also for any rounding errors in the TMDL calculation (calculation format shown below). Expressing the TMDL in terms of this simple equation makes it easier to see where pollution reduction efforts need to be focused. In other words, which sources can be reduced to reach the final TMDL number, by how much they need to be reduced, and which pollution sources are not practical for reduction. The sources that make up the final TMDL number are categorized as either Load Allocation (LA) or Waste Load Allocation (WLA). LAs are all non-point source loads, meaning that they do not come from a single source or pipe. LAs include agricultural runoff, forest runoff, and upstream loads. WLAs are all point source loads, meaning that they do come from a single traceable source. WLAs are further categorized as process water or stormwater. Process water WLA comes from sources that have permits allowing them to release a specific amount of a pollutant into the water. They include individual industrial facilities, individual municipal facilities, and mineral mining facilities. Stormwater WLA is any stormwater that is regulated by a municipal separate storm sewer systems (MS4) permit, water from industrial facilities permitted to release stormwater, and all runoff from construction sites.

All Baltimore County urban stormwater is regulated under Baltimore County's MS4 permit. That means that stormwater WLA includes all of the water that runs to any storm drain within the watershed area. The MOS is the final part of the equation. The MOS can be implicit, meaning that the final TMDL was calculated in such a way that it accounted for any errors without needing to tack an explicit MOS to the end of the sum of load sources equation. When an explicit MOS is necessary, it is assumed that a 5% reduction of the final TMDL number will be sufficient.

TMDL Sum of Load Sources Equation:

$$\textbf{TMDL} = \textbf{LA} + \begin{array}{c}\textbf{WLA}\\ \textbf{Stormwater}\end{array} + \begin{array}{c}\textbf{WLA Process}\\ \textbf{Water}\end{array} + \textbf{MOS}$$

1.1.1 How is the Final TMDL Determined?

The process of determining the TMDL number can be very complex. Pollution data are regularly collected throughout Maryland by many different federal, state, and local government agencies as well as universities and watershed organizations. The agency or organization may send individuals out to the stream to collect and measure information about the watershed as part of a study or regular monitoring program. Data are also collected from the many different monitoring stations that are located throughout Maryland's watersheds. Some of these monitoring stations have been collecting water data for decades. The U.S. Geological Survey and the Maryland Department of Natural Resources monitoring stations are often used as the data source for Maryland TMDLs. To find out who is keeping an eye on your watershed see MDE's Water Quality Monitoring Web Page.

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Complex scientific models are often used to help find a practical number for the total reduction. Models often use existing monitoring data and observations about the watershed area in a calculation that determines the TMDL number. The type of model used and the complexity of the model vary by pollutant, water body type, and complexity of flow conditions. The specific model used for this TMDL is explained in Section 3.

In all cases, scientists first find a baseline load for the pollutant. The baseline load is how much of the pollutant is in the water body at the time of the study, before restoration actions specifically developed to reach the TMDL number are implemented. The calculated target number, that is the TMDL, is the final goal. It could be thought of as the finish line in the TMDL process. That is not to say that other restoration efforts will not continue once that target is reached, but that the water body will be able to meet state water quality standards and can be removed from the list of impaired and threatened waters for that particular pollutant.

When calculating the TMDL number, a percent reduction and load reduction are usually calculated as well. The load reduction is the difference between the baseline load and the TMDL target. Think of it as the amount that needs to be removed from the system in order to reach the target. The percent reduction is the percentage of the baseline load that needs to be removed in order to reach the TMDL target.

1.2 Geographic Area

Pollution reduction goals are determined by watershed. A watershed is all the land area where all of the water that runs off that land and all the water running under that land drain into the same place. Everything within a watershed is linked by a common water destination. Watersheds exist at many levels: some very large, and some quite small. Identifying your watershed is similar to identifying your current location on a map. You could say you are in the United States, or that you are in Maryland, or that you are in your kitchen at your specific street address. Similarly, you could say that you are in the Mid-Atlantic Region Watershed, which drains to the Atlantic Ocean, Long Island Sound and Riviere Richelieu, a tributary of the St. Lawrence River. You could also say that you are in the Upper Chesapeake Bay Watershed, which includes the area of drainage to the Chesapeake Bay that is north of the Maryland-Virginia line. Both would describe a watershed that you are located in. However, watersheds can become much more specific.

A system was established by the U.S. Geological Survey for dividing the U.S. into successively smaller hydrologic units. Each hydrologic unit is identified by a hydrologic unit code (HUC), which range from two to twelve digits. The smaller the scale of the watershed, the more digits it has in its code. For example, the Mid-Atlantic Region is a 2-digit watershed and the Upper Chesapeake Bay is a 4-digit watershed. The 6-digit unit, also known as the "basins" unit, is to serve as the common scale for watershed assessments at the national level, but the condition of these basins can be determined based on an aggregation of assessments of even smaller watershed units. Maryland has chosen to go the route of assessing smaller watershed units. As a result, TMDLs are determined at the 8-digit watershed scale. For a further explanation of HUCs or to see maps of watersheds at different HUC levels, go to: USGS Hydrologic Unit Maps. If you would like to know which Maryland 8-digit watershed you are located in, go to MDE's Find My Watershed Map.

It is important to note that 8-digit watersheds can overlap multiple counties and may, therefore, have several regulating authorities. It is important to know that in certain water bodies, such as Loch Raven Reservoir, there is an upstream contribution impacting water quality. Prettyboy Reservoir is upstream of Loch Raven in the Gunpowder River system. Its watershed includes portions of Baltimore, Carroll and Harford counties in Maryland, and York County, PA.

1.2.1 Loch Raven Reservoir Watershed

The Loch Raven Reservoir is an 8-digit watershed (02-13-08-05) that covers a total land area of 303 square miles. Loch Raven Reservoir watershed is located mostly in Baltimore County with small portions in Carroll and Harford counties in Maryland, and York County, Pennsylvania. Land use in the Loch Raven Reservoir watershed (entire) is composed of approximately 36.6% forest, 37.9% agriculture, 24.0% urban, and 1.5% water. This TMDL Implementation plan will specifically address the land area of the watershed and tributaries that are located in Baltimore County (Figure 1.1).

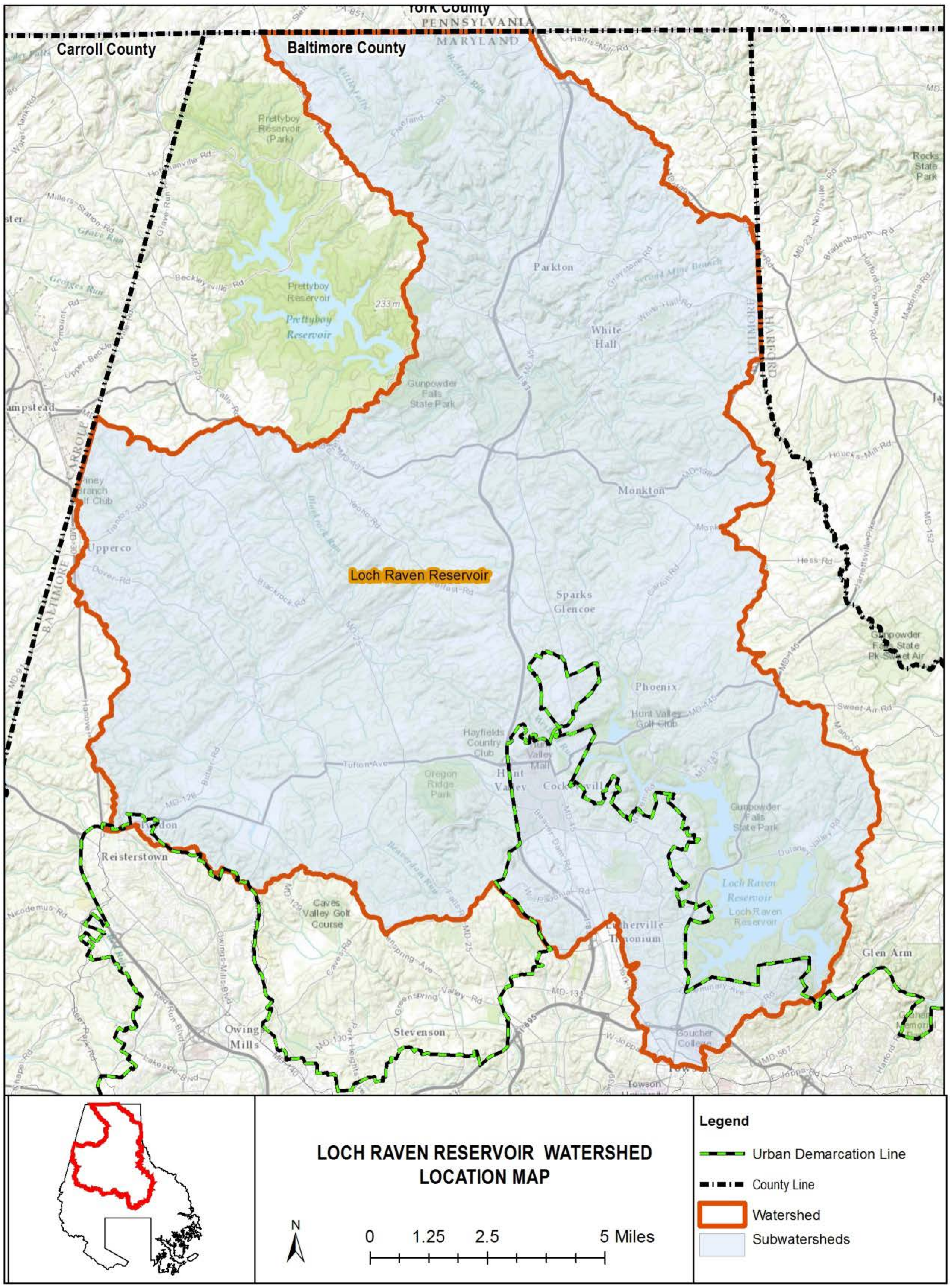

Figure 1.1: Loch Raven Reservoir Watershed, Baltimore County Portion

1.3 Goal of the TMDL Implementation Actions

TMDL Implementation Plan Objective:

Through a cooperative effort of Baltimore County Department of Environmental Protection and Sustainability, other county agencies, local watershed associations, and the general public, to provide a comprehensive plan of action for achieving TMDL targets and ultimately restoring the health of Baltimore County waters to acceptable water quality standards.

Baltimore County is required to reduce pollution in its waterways; the plans to meet these reductions need to be in place by December 23, 2014. More on the legal requirements for these implementation plans will be discussed in depth during Section 2 of this document. The goal of this IP is to set the "road map" for the county to reach the goal of reducing pollutant loads in the water to meet water quality standards.

1.4 Document Organization

The Baltimore County TMDL implementation plans provide the following information to explain the necessity of the TMDL Implementation Plan and to develop a management strategy that will be followed in order to meet county TMDL reduction targets. The County will take an adaptive management approach that will include periodic assessments to determine progress and identify changes needed in the management strategy to meet the reduction targets in a timely, cost effective manner.

Section 1: Introduction

This Introduction states the pollutant that is being addressed by the TMDL IP, and the watershed for which the IP was developed. It provides a background on what a TMDL is and how the TMDL is determined. A general description of the geographic area for the specific IP is provided. The Introduction also states the overall goal of the TMDL IP and summarizes the actions that have been identified to bring Baltimore County to that goal. It also includes a brief summary of the contents of the thirteen sections of the TMDL Implementation Plan.

Section 2: Regulatory Policy and Planning

This part of the document describes the administration and legal authority that mandates the development of Baltimore County's TMDL implementation plan and oversees its fulfillment. It will provide a background of how various regulating authorities and policies are related to the requirement to develop a TMDL Implementation Plan. It will also summarize the various planning guidance documents that have been produced to assist in the development of TMDL Implementation Plans and how TMDL Implementation Plans fit in the overall Baltimore County planning context.

Section 3: TMDL Summary

The section summarizes the original TMDL document that was submitted by MDE and approved by the EPA. The summary includes: when the TMDL was developed, what is impaired, why the TMDL was developed, a description of the analysis process that was used to determine the total maximum daily load targets, the baseline year of data collection and analysis, the results from that analysis, and a further break down of the target loads by source sector.

Section 4: Literature Summary

Each TMDL IP will address a specific pollutant. This part of the document provides an overview of the pollutant that is summarized from published literature. The literature summary includes known sources of the pollutant, the impacts associated with the pollutant, the pathways and transformations of the pollutant, and other relevant ecological processes that affect how the pollutant can be controlled and regulated.

Section 5: Watershed Characterization

Characterization of the watershed will include geographical and technical information for the portion of the watershed that is specific to each TMDL IP. Each characterization will describe the watershed acreage, population size, geology and soils, topography, land use, streams, infrastructure related to watershed pollution sources, implemented restoration projects since the baseline year, and changes in pollutant load since the baseline year.

Section 6: Existing Data Summary

This section will include a summary of Baltimore County's existing monitoring data that will be pertinent to the pollutant in question. It may also include some data received from sources other than Baltimore County, such as data from the Maryland Department of the Environment, or other relevant sources.

Section 7: Summary of Existing Restoration Plans

Previous planning efforts will be summarized in this section. Water Quality Management Plans (WQMP) and Small Watershed Action Plans (SWAP) applicable to the IP area are identified. The process and goals for SWAP development are explained. A description of SWAP actions can also be found in this section. The actions include potential or operative actions that may help meet the TMDL targets. A comparison is made between the pollutant load reductions as a result of SWAP actions and the final TMDL load reduction target.

Section 8: Best Management Practice Efficiencies

This section is an explanation of the best management practices that will be used for removing the particular pollutant and the known efficiency of those best management practices. A table will be found in this section of BMPs and the known reduction efficiency for the pollutants that can be reduced by each BMP. BMP efficiencies will also include a discussion of the uncertainty and research needs for BMPs.

Section 9: Implementation

The implementation section will provide a description of programmatic, management, and restoration actions; and pollutant load reduction calculations to meet the pollutant reduction target for the specific pollutant. For each of the programmatic, management, and restoration actions there will be a list of responsible parties, actions, timeframe of actions, and performance standards.

Section 10: Assessment of Implementation Progress

Assessment of implementation progress will give Baltimore County a formal method of reporting on the development of implementation and of describing the progressive success of implementation actions. The section will include a description of tracking and reporting mechanisms, and a monitoring plan that includes progress monitoring as well as BMP effectiveness monitoring.

Section 11: Continuing Public Outreach Plan

This part of the document will be a continuing public outreach plan. It will encourage public involvement in the implementation process, extending beyond the finalization of this document.

Section 12: References

A list of references used in the creation of this document.

Section 2 - Legal Authority, Policy, and Planning Framework

The Legal Authority, Policy, and Planning Framework section will present, in brief, the background on the legal requirements that pertain to the development of Total Maximum Daily Loads (TMDLs), and the preparation of TMDL Implementation Plans. This section will also cover the planning framework for the development of the TMDL Implementation Plans (IP). Furthermore, this section is intended to provide the context for the development of this TMDL Implementation Plan and understanding of the linkage between water quality and the TMDL.

Whether at the federal or state level there are a number of processes at work that result in the regulations that must be followed to remain within the law. First, legislation is passed by an elected governing body (e.g. Congress, state legislature), and once passed and signed by the executive branch, they become Acts (laws), such as the Clean Water Act. In order to provide guidelines in maintaining compliance with these laws, it is often necessary that regulations be issued to specify the law's requirements. A regulation is a rule issued by a government agency that provides details on how legislation will be implemented, and may set specific minimum requirements for the public to meet if they are to be considered in compliance with the law. These regulations may come in various forms, such as the Code of Federal Regulations (CFR), or Code of Maryland Regulations (COMAR). The information that follows is generally taken from CFR and COMAR.

Under the Code of Federal Regulations (CFR), Title 40 encompasses the regulations enforced by the U.S. Environmental Protection Agency (EPA). These regulations include not only those related to water quality, but also air quality, noise, and a variety of land based regulations (oil operations, etc.)

2.1 Regulatory and Policy Framework

The ultimate regulatory authority for protecting and restoring water quality rests with the federal government through legislative passage of the Clean Water Act in 1972 and subsequent amendments. Prior to the Clean Water Act (1972), the Federal Water Pollution Control Act (1948) served as the basis for controlling water pollution. The Clean Water Act significantly amended the Federal Water Pollution Control Act and established the basic structure for regulating discharges of pollutants into the waters of the United States. Major amendments were enacted in 1977 and 1987 that further strengthened and expanded the Clean Water Act of 1972. The 1987 amendments incorporated the requirement that stormwater discharges from urban (municipal) areas be required to obtain a permit for discharge and that stormwater discharges from industrial sources also be permitted. There have been a number of minor amendments and reauthorizations over the years that have resulted in the law as it now stands.

There are several significant provisions of the Clean Water Act that pertain to TMDLs. These provisions include the requirement that states adopt Water Quality Standards by designating water body uses and set criteria that protect those uses. The Clean Water Act also requires states to assess their waters and provide a list (known as the 303(d) list) of waters that are impaired. The list specifies the impairing substance and requires that a TMDL be developed to address the impairment.

Through policy (memos dated November 22, 2002 and November 12, 2010) the US EPA has indicated that the pollutant loads attributable to regulated stormwater discharges are to be included in the Waste Load Allocation as a point source discharge and not as part of the non-point load. The initial memo also affirmed that the Water Quality-Based Effluent Limitations (WQBELs) in Municipal Separate Storm Sewer System (MS4) permits may be expressed in the form of Best Management Practices (BMPs) and not as numeric limits for stormwater discharges. The second memo clarified that when the MS4 permits are expressed in the form of BMPs, the permit should contain objectives and measurable elements (e.g., schedule for BMP installation or level of BMP performance). By providing both an expected level of BMP performance and a schedule of implementation of the various practices, Baltimore County will have addressed this requirement. This plan once approved by Maryland Department of the Environment (MDE) will be enforceable under the terms of the permit.

2.2 Maryland Use Designations and Water Quality Standards

In conformance with the Clean Water Act, the State of Maryland has developed use designations for all of the waters in the state of Maryland, along with water quality standards to maintain the use designations.

Designated uses define an intended human and aquatic life goal for a water body. It takes into account what is considered the attainable use for the water body, for protection of aquatic communities and wildlife, use as a public water supply, and human uses, such as recreation, agriculture, industry, and navigation. Water quality standards include both the Use Designation and Water Quality Criteria (numeric standards). Water Quality Criteria are developed to protect the uses of a water body.

2.2.1 Use Class Designations

Every stream, lake, reservoir, and tidal water body in Maryland has been assigned a Use Designation. The Use Designation is linked to specific water quality standards that will enable the Designated Use of the water body to be met. A listing of the Use Designations follows:

- Use Class I: Water contact recreation, and protection of nontidal warm water aquatic life.
- Use Class II: Support of estuarine and marine aquatic life and shellfish harvesting (not all subcategories apply to each tidal water segment)
  - Shellfish harvesting subcategory
  - Seasonal migratory fish spawning and nursery subcategory (Chesapeake Bay only)
  - Seasonal shallow-water submerged aquatic vegetation subcategory (Chesapeake Bay only)
  - Open-water fish and shellfish subcategory (Chesapeake Bay only)
  - Seasonal deep-water fish and shellfish subcategory (Chesapeake Bay only)
  - Seasonal deep-channel refuge use (Chesapeake Bay only)
- Use Class III: Nontidal cold water – usually considered natural trout waters
- Use Class IV: Recreational trout waters – waters are stocked with trout

The letter "P" may follow any of the Use Designations, if the surface waters are used for public water supply. There may be a mix of Use Classes within a single 8-digit watershed; for example, Gwynns Falls has Use I, Use III, and Use IV Designations depending on the subwatershed.

Table 2.1: Designated Uses and Applicable Use Classes

Designated Uses	Use Classes							
	I	I-P	II	II-P	III	III-P	IV	IV-P
Growth and Propagation of fish (not trout), other aquatic life and wildlife	✓	✓	✓	✓	✓	✓	✓	✓
Water Contact Sports	✓	✓	✓	✓	✓	✓	✓	✓
Leisure activities involving direct contact with surface water	✓	✓	✓	✓	✓	✓	✓	✓
Fishing	✓	✓	✓	✓	✓	✓	✓	✓
Agricultural Water Supply	✓	✓	✓	✓	✓	✓	✓	✓
Industrial Water Supply	✓	✓	✓	✓	✓	✓	✓	✓
Propagation and Harvesting of Shellfish			✓	✓				
Seasonal Migratory Fish Spawning and Nursery Use			✓	✓				
Seasonal Shallow-Water Submerged Aquatic Vegetation Use			✓	✓				
Seasonal Deep-Water Fish and Shellfish Use			✓	✓				
Seasonal Deep-Channel Refuge Use			✓	✓				
Growth and Propagation of Trout					✓	✓		
Capable of Supporting Adult Trout for a Put and Take Fishery							✓	✓
Public Water Supply		✓		✓		✓		✓

2.2.2 Water Quality Criteria

Water quality criteria are developed to protect the uses designated for each water body. Certain standards apply over all uses, while some standards are specific to a particular use. The criteria are based on scientific data that indicate threats to aquatic life or human health. For the protection of aquatic communities the criteria have been developed for fresh water, estuarine water, and salt water. The criteria have been further based on acute levels (have an immediate negative effect) and chronic levels (have longer term effects). The human health criteria are based on drinking water levels, organism consumption levels, or a combination of drinking water and organism consumption levels, or recreational contact bacteria levels.

Dissolved oxygen criteria for all Use Designations is 5 mg/L, except for Use II Designations and special criteria for drinking water reservoir hypolimnion waters (bottom waters of the reservoir).

Bacteria criteria are based on human health concerns, and apply to all Uses, with additional bacteria criteria applicable in shellfish waters. Since none of the local TMDLs are related to the shellfish criteria, they are not discussed here. The human health criteria are based on either the geometric mean of 5 samples or single sample criteria based on the frequency of full body contact, these criteria are displayed in Table 2.2. For the freshwater bacteria TMDLs the indicator bacteria *E. coli* has been used in the development of the TMDL, therefore serves as the water quality end point. The human health recreational contact bacteria criteria are displayed in Table 2.2. The table displays both the geometric mean for bacteria and single sample maximum allow bacteria concentrations based on the frequency of full body contact.

Table 2.2: Bacteria Criteria for Human Health (MPN/100 ml)

Indicator	Steady State Geometric Mean Density	Single Sample Maximum Allowable Density			
		Frequent Full Body Contact Recreation	Moderately Frequent Full Body Contact Recreation	Occasional Full Body Contact Recreation	Infrequent Full Body Contact Recreation
Freshwater (Either Apply)					
Enterococci	33	61	78	107	151
E. coli	126	235	298	410	576
Marine					
Enterococci	35	104	158	275	500

2.3 Planning Guidance

In March of 2008 the EPA released a guidance document on the development of watershed plans entitled *Handbook for Developing Watershed Plans to Restore and Protect Our Waters*. The handbook laid out nine minimum elements to be included in watershed plans, commonly called the "a through i" criteria. The criteria include:

a. An identification of the causes and sources or groups of sources that will need to be controlled to achieve the load reductions estimated in the watershed plan.

b. Estimates of pollutant load reductions expected through implementation of proposed Non-point Source (NPS) management measures.

c. A description of the NPS management measures that will need to be implemented.

d. An estimate of the amounts of technical and financial assistance needed to implement the plan.

e. An information/education component that will be used to enhance public understanding and encourage participation.

f. A schedule for implementing the NPS management measures.

g. A description of interim, measurable milestones for the NPS management measures.

h. A set of criteria to determine load reductions and track substantial progress towards attaining water quality standards.

i. A monitoring component to evaluate effectiveness of the implementation efforts over time.

EPA now evaluates watershed plans on the basis of the above criteria in consideration of its grant funding. The State of Maryland is also increasingly using the above criteria for funding consideration. Baltimore County has used these criteria since the publication of the handbook in the development of its Small Watershed Action Plans; and will use the criteria in the development of this TMDL Implementation Plan.

Maryland Department of the Environment (MDE) developed a guidance document in conjunction with local government representatives entitled *Maryland's 2006 TMDL Implementation Guidance for Local Governments*, which provides a framework for the development of TMDL Implementation Plans. MDE has also provided guidance on the development of TMDL Implementation Plans related to specific pollutants. Guidance for specific pollutants includes:

- PCBs
- Bacteria
- Mercury
- Trash

These guidance documents have been taken into consideration in the development of the Baltimore County TMDL Implementation Plans.

2.4 Water Quality Standards Related to This Implementation Plan

There are no specific standards related to the rate of infill of reservoirs. However, to protect water supplies and to manage drinking water reservoirs to provide adequate quantity and quality water for current and future human consumption, it is necessary to extend the life of the reservoir through reduction of the infill rate. The sediment TMDL is tied directly to the phosphorus TDML through the use of the phosphorus/sediment ratios and only requiring a sediment reduction that can be met through the actions needed to reduce phosphorus.

The TMDL summary provides context for the TMDL Implementation Plan. It is necessary to understand some basic information from the original TMDL document that preceded this particular Implementation Plan. The TMDL document describes the condition of the watershed at the time that the baseline load of the pollutant was calculated. The baseline load is simply a measurement of the amount of the pollutant that was in the waterbody during a specific time. The baseline load provides a starting pollutant measurement for the county to reduce from, in order to meet the TMDL target. The term TMDL is also used to describe the specific numeric load target, which is explained in detail within the TMDL document. The original TMDL document provides a detailed justification for choosing the TMDL target number. This justification is a description of the entire technical process including monitoring methods and calculations. The following section is a simplification and summary of that section of the TMDL document and a brief explanation of why the TMDL was developed for the specific pollutant in this watershed.

3.1 TMDL Background

- **The Problem**: The TMDL was developed because sedimentation was found to be decreasing the storage capacity for water supply in the Loch Raven Reservoir.

The Loch Raven Reservoir was listed as being impaired by sediment in 1996. MDE developed the TMDL and submitted it to EPA in 2002. It was approved by EPA in 2007.

As stated in the TMDL document by Maryland Department of the Environment excessive sediment infill in a reservoir decreases the available storage capacity for public water supply and decreases the useful life of a reservoir. In addition, sediment infill can have a negative effect on fishing and recreational uses. Peak sedimentation rates occur during storm events but the accumulation of sediments over time is what impacts the reservoir. There is not one critical period of time that can be attributed to the water quality impact of sedimentation; sediment infill in reservoirs has a negative impact regardless of when it occurs. Efforts to decrease sedimentation in the Loch Raven Reservoir will strive to achieve long term effective control.

The Hydrologic Simulation Program-Fortran (HSPF) was used to estimate the stormwater loads entering the Loch Raven Reservoir, through flows, suspended solids and nutrients loads from sub basins. The model also integrates all natural and human sources. These estimates are used to determine the maximum loads of what can enter the reservoir while maintaining the water quality criteria associated with the waterbody’s designated uses. The following assumptions were used to simulate the watershed: (1) patterns of precipitation were estimated using data from the National Oceanic and Atmospheric Administration (NOAA); (2) hydrological responses were estimated for a simplified set of land uses; (3) agricultural information was estimated using the Maryland Department of Planning land use data, the 1997 Agricultural Census Data and the Farm Service Agency.

These reductions will allow for the retention of 85% of the reservoir’s original volume after 50 years. This will also reduce the loss of volume in the upper reservoir which is on track to be at 70% of its original capacity in 50 years. The TMDL document that addresses sediment in Loch Raven Reservoir also addresses phosphorus in both Loch Raven Reservoir and Prettyboy

Reservoir. Sediment and phosphorus pollutants are directly related. Phosphorus binds to sediment particles and is transported into a waterbody with erosion.

3.2 TMDL Development

A critical step in the TMDL process is establishing the method by which the TMDL targets will be determined. In 1998, the Maryland Geological Survey (MGS) completed a bathymetry survey of Loch Raven Reservoir which was used to estimate sedimentation rates. The average annual sedimentation rate can be described as, the percent of the reservoir capacity that was lost, sediment accumulation in inches each year, or tons/mi^2/yr. The Reservoir Technical Group (RTG) estimated the rate based on the bathymetric survey. RTG is a consortium of local jurisdictions that share the municipal water supply; it is managed by the Baltimore Metropolitan Council.

This survey showed that the annual percent capacity loss in volume of the Loch Raven Reservoir is 0.13%, which is lower than the national average of 0.43% for similar sized reservoirs. Also, the results of this survey showed that sediment accumulation is not evenly distributed throughout the reservoir. For example, Dulaney Valley Branch lost 8% of its capacity and Long Quarter Branch lost 13%. These findings were the basis for the creation of this TMDL.

This particular TMDL was developed using four different scenarios.

(1) Calibration Scenario which represents actual load over the period of 1992-1997.

(2) Baseline Scenario also represents actual loads from 1992-1997 but is used to determine loads from waste water treatment plants and point source discharges.

(3) TMDL Scenario which represents maximum loads for non-point sources and developed land which fall under the NPDES stormwater permits.

(4) All-Forest Scenario simulates the affect a completely forested watershed would have on the sediment loading rate.

The results of these scenarios show that wastewater treatment plants and point sources contribute an insignificant amount of sediment to the Loch Raven Reservoir. In the All-Forest Scenario the loads simulated for particulate organic matter (POM) were 41% of those in the Calibration Scenario and the loading rates of POM and total phosphorus (TP) were reduced to 50%, 20% and 10%.

As previously stated, practices to control phosphorus can effectively reduce sediment at the same time. The EPA estimates that there is a 1 to 1 ratio for the reduction of sediments resulting from practices to reduce phosphorus. But, this does not take into account phosphorus reduction efforts that do not effect sediment. Overall, it is assumed that there will be a .5 to 1 ratio for sediment to phosphorus reduction, therefore if phosphorus is reduced by 50%, sediment will be reduced by about 25%. As a result of the reduced sediment loading rate there will be a similar reduction in the sediment accumulation rate.

3.3 TMDL Results

The estimated reduction in accumulation and loading rates as discussed in the previous section, would allow for 85% of the reservoir's original volume to be retained in 50 years. This is especially important for the upper reservoir area which would have had less than 70% of its original storage capacity in 50 years. The volumetric retention of the reservoir will support its designated use, the public water supply and naturally-breeding trout.

In actuality, there is no target load reduction for this TMDL. However, since the baseline was determined there has been an increase in load. In order to reach the baseline, with no reductions needed, the increase since the baseline (385 tons/year of sediment) will need to be addressed. Therefore, there is a need to reduce sediment loading to the reservoir by 385 tons/year. See Section 5 for a more detailed explanation of the data.

3.4 TMDL Reductions Targets by Source Sector

TMDLs must be presented as a sum of Waste Load Allocations (WLA) for point sources, Load Allocations (LA) for non-point sources, and a Margin of Safety (MOS).

- LA: Non-point sources consist of agricultural and forests loads in this TMDL
- WLA: The WLA consists of two permitted sources: waste water treatment plant (WWTP) WLA and permitted industrial facilities WLA.
    - The Hampstead WTTP makes up the allowable load. The current permit flow of .09 MGD is used and the total suspended solids limit is 30.0 mg/1 year round.
    - There are three permitted industrial facilities which have permits that regulate the discharge of TSS. Only the Lafarge Mid Atlantic and Imerys Facility have the ability to discharge significant sediment loads to the reservoir. The waste load allocation for the facility was determined by the maximum average discharge from the two permitted outfalls with a suspended solids limit of 15 mg/l and 17 mg/l. The WLA for the other two facilities was also determined by the maximum recorded average flow and suspended solid concentrations.
- MOS: The Margin of Safety is implicit because the forest normalized sediment load was considered to be an environmentally conservative estimate.

Table 3.1: TMDL Allocation as a Sum of Load Allocation, Waste Load Allocation, and Margin of Safety

LA[1]	27,715
WLA	1,210
MOS	Implicit
Total	28,925

1. The LA includes the upstream load allocation, which was used in calculating the final TMDL

This review pertains to direct and indirect effects of sediment on the Loch Raven Reservoir. This is not intended to be an exhaustive review of primary literature, but rather a summary of the sources, pathways and biological effects of sediment in reservoirs from literature available to Baltimore County Department of Environmental Protection and Sustainability.

Sediment is solid soil or rock material (e.g. pebbles, sand, dirt, mud, particulate organic material) that is transported by wind, water or ice, or is secreted or carried by organisms, or precipitated from a solution, i.e., chemical sedimentary rocks (U.S. Geological Survey and U.S Department of the Interior 2003). The effects of sediment on a water ecosystem are multi-dimensional (Berry, Rubinstien and Melzian 2003). The vulnerability of a reservoir to sedimentation is dependent on the sediment delivery rates, retention characteristics of the reservoir and the method of water flow delivery to the reservoir (Department of the Environment 2001).

Classifications of sedimentation include bottom deposition and suspended sediment. Deposited sediment includes particles that are typically transported along the bottom of a water body while silt and clay sediments usually become suspended in the water column. Turbidity is a measure of the water's cloudiness as a result of suspended sediment. Suspended sediment can include material that is large enough to eventually settle as bottom deposition. It can also include particles that fluctuate, through natural processes, between suspensions and deposition. Suspended sediment particles that are small enough to settle very slowly, or not at all, are those that contribute to the problem of turbid water (Berry, Rubinstien and Melzian 2003). The rate of flow of the waterbody determines what size particles become suspended or deposited (Davis 2009). Faster moving water has the power to move larger particles. Because the rate of water flow changes with water volume, the maximum size of particles in suspension is also subject to change. See USGS Summary Report on Sediment Processes: Chapter 3Watershed Sediment Transport and Chapter 4 Watershed Sediment Deposition and Storage. By the processes of re-suspension and deposition sediment can be re-introduced into the water column or deposited to the river or stream bed (Colorado Department of Public Health and the Environment Water Quality Control Commission Water Quality Control Division 2005).

Generally the process for sediment deposition is that as a water flow enters a reservoir the channel cross sectional area increases, the flow velocity decreases and water turbulence causes sediment particles to be deposited (Department of the Environment 2001). Overtime sediments accumulate on the bottom and reduce the capacity of the reservoir to store water for municipal supply. The rate at which sediment fills in directly translates to the life expectancy of a reservoir (Graf, et al. 2010). Fluctuations in the sediment load occur naturally and are a vital part of the aquatic system. Sediment stress results when significant changes to the normal sediment load occur, compromising the ecological integrity of the water ecosystem (Berry, Rubinstien and Melzian 2003).

The distribution of sediment infill depends on several factors including the size and texture of sediment particles and the physical characteristics of a reservoir. Usually, the first layer of deposited sediment is of larger coarser particles which form a delta in the headwaters. These beds gradually move towards the reservoir forming a slope down into the reservoir. Finer particles are carried further down the reservoir and can form additional beds (Department of the Environment 2001).

Sediments enter the waterbody through a wide variety of transport mechanisms, including surface water (e.g. stormwater runoff), bank sloughing, and atmospheric deposition. See the USGS Summary Report on Sediment Processes: Chapter 2 Watershed Sediment Sources. Upland and bank erosion contribute to non-point sources of the sediment load. Anthropologic activities enhance the erosion process (Booth and Henshaw 2000). Those activities include construction, mining, farming, urban development, and dredging (Berry, Rubinstien and Melzian 2003).

Erosion rates differ by land use. Estimates of average annual erosion rates help to determine the amount of sediment delivered to the water body, but not all eroded sediment enters the river. The average annual erosion rate from the land is known as the edge-of-field (EOF) erosion, but the edge-of-stream (EOS) is what actually enters the river reaches. The EOS is calculated using the EOF, but also takes into account the deposition of sediment on hillsides, and sediment transport through smaller streams and rivers (Maryland Department of the Environment 2011).

Stream bank erosion is aggravated by high water flows during storm events. Impervious surfaces, such as parking lots, roads, and rooftops are directly connected to the stream channel via the storm sewer system. This causes water to flow more rapidly into the waterbody during a storm event without the natural filtration that occurs when rain water runs through vegetation and soil. The outcome is higher water flows in the stream channel during storms and higher sediment content in the streams and rivers which feed the reservoir. The stress of these high flows through the stream and river channels wears away at the banks, causing higher than normal bank erosion (Booth and Henshaw 2000) (Maryland Department of the Environment 2011).

A study produced by U.S. Geological Survey on sediment processes in the Chesapeake Bay watershed found that river basins with the highest percentage of agricultural land use have the highest annual sediment yields (U.S. Geological Survey and U.S Department of the Interior 2003). Basins with the highest percentage of forest cover were found to have the lowest annual sediment yields. The study also found that urbanization can more than double the background sediment yield (U.S. Geological Survey and U.S Department of the Interior 2003). This urban sediment is highest during construction phases and then declines after the initial development is complete. In some instances, when construction alters stream hydrology, the sedimentation rate remains high because the erosion of stream banks continues long after development (U.S. Geological Survey and U.S Department of the Interior 2003). For more information on urbanization and sedimentation, see: U.S. EPA Urbanization and Streams: Studies of Hydrologic Impacts.

Sediment can affect humans by reducing water clarity, which is not aesthetically pleasing. It can also reduce cleanliness of water for swimming or recreational activities, as well as drinking.

An overabundance of suspended sediment in the water column, resulting in cloudy water, inhibits light penetration. This can be a problem for predators, as both big and small fish hunt primarily by sight (Berry, Rubinstien and Melzian 2003) (Lester 2013). When fish and other aquatic animals cannot see their prey, their ability to capture food is limited. Murky water is a problem for both large and small fish, but smaller fish that feed on zooplankton can have an advantage, to a degree, of not being seen as easily by predators while scavenging for food. However, too much cloudiness, negates this advantage and both large and small fish will find it difficult to get enough food for their survival (Lester 2013).

Excessive deposited sediments can also destroy valuable aquatic habitats for fish, aquatic invertebrates, and algae (Berry, Rubinstien and Melzian 2003) (Lisle 1989). Fish habitats are affected when fine sediment settles into spawning gravels, reducing oxygen levels in the spaces between gravel particles. Spawning gravels are stream bed materials that females excavate to form nests for egg laying. During excavation, females minimize fine sediment particles to enhance gravel permeability and oxygenate the eggs. Decreased oxygenation due to sedimentation can lead to a reduction in survival and growth rates (Colorado Department of Public Health and the Environment, 2005; Lisle, 1989). Sedimentation can also negatively affect fish through loss of food sources and loss of habitat variety that normally result from natural variations in steam morphology (Colorado Department of Public Health and the Environment Water Quality Control Commission Water Quality Control Division 2005).

Another way that sediments can damage the health of aquatic communities is by transporting pollutants into the watershed. Nutrients and metals can form complexes with minerals found in fine sediment, consequently, water runoff not only carries excessive sediments, but often includes pollutants as it washes into waterways. Excess of certain nutrients and minerals can be toxic to many aquatic organisms (Nelson and Booth 2002). For example, excess phosphorus in the water increases the growth of surface level algae. The algae can block out sunlight and prevent it from getting to the submerged aquatic vegetation (SAV), which is an essential part of the aquatic food chain. Excessive algae growth also uses up oxygen in the water and can create hypoxic conditions, meaning that the dissolved oxygen level is too low to support many aquatic organisms. See USGS Summary Report on Sediment Processes: Executive Summary.

When sediment accumulates in “active storage” areas of a reservoir which are areas that water is being drawn out of, there are several effects including the reduction of available space for water resources. The American Society of Civil Engineers Sedimentation handbooks states that in order for a reservoir to maintain its function, replacement storage needs to be implemented when 15% to 40% of the storage is lost (Utah Division of Water Resources 2010).

Other past literature on sediment in aquatic systems include: Waters (1995), Naiman and Baily (1998), Reid and Dunne (1996), Wilber and Clarke (2001), Nietch and Borst (2001), and Leopold et al. (1964), as reviewed in (Berry, Rubinstien and Melzian 2003).

Section 5 - Watershed Characterization

This section will describe the watershed characteristics of the Baltimore County portion of the Loch Raven Reservoir watershed. Section 5.1 has general characterization information and Section 5.2 discusses land use, sediment loads and reductions and the total reduction required to meet the TMDL. Characterizing the watershed can aid planning and restoration targeting efforts and improve understanding of sediment sources. Note that all references to the Loch Raven Reservoir watershed are referring to the Baltimore County portion of the watershed only.

The TMDL document produced by MDE used 1997 as the baseline year for data in determining the sediment load reduction required (Maryland Department of the Environment, 2006). Figure 5.1 shows the Loch Raven Reservoir watershed.

5.1 General Info

5.1.1 Acreage

The Baltimore County portion of the Loch Raven Reservoir watershed contains 139,577 acres of land with varying usages and pollution potential. Figure 5.1 shows the Loch Raven Reservoir watershed.

5.1.2 Population

Population data provides another way to evaluate the intensity of land use. Much of the degradation from urban/suburban land uses (where population is mainly concentrated) is related to the extent of impervious cover and also conversion of land uses that protect water resources such as forest. A higher population density (persons per acre) represents a more intense use of the land and potential for environmental degradation.

Census block data from the 1990 US Census and 2010 US Census was used to determine the population in the watershed. Data from the 1990 US Census was interpolated in order to estimate the population for 1997, which is the baseline year for the TMDL and therefore important to understand the conditions at the time the TMDL was developed. Population for 1997 and 2010, and the percent change over time, in the Loch Raven Reservoir watershed is shown in Table 5.1.

Table 5.1: Population Data for Loch Raven Reservoir Watershed (Baltimore County)

	1997	Current	% Change
Loch Raven Reservoir	82,337	89,442	+8.6

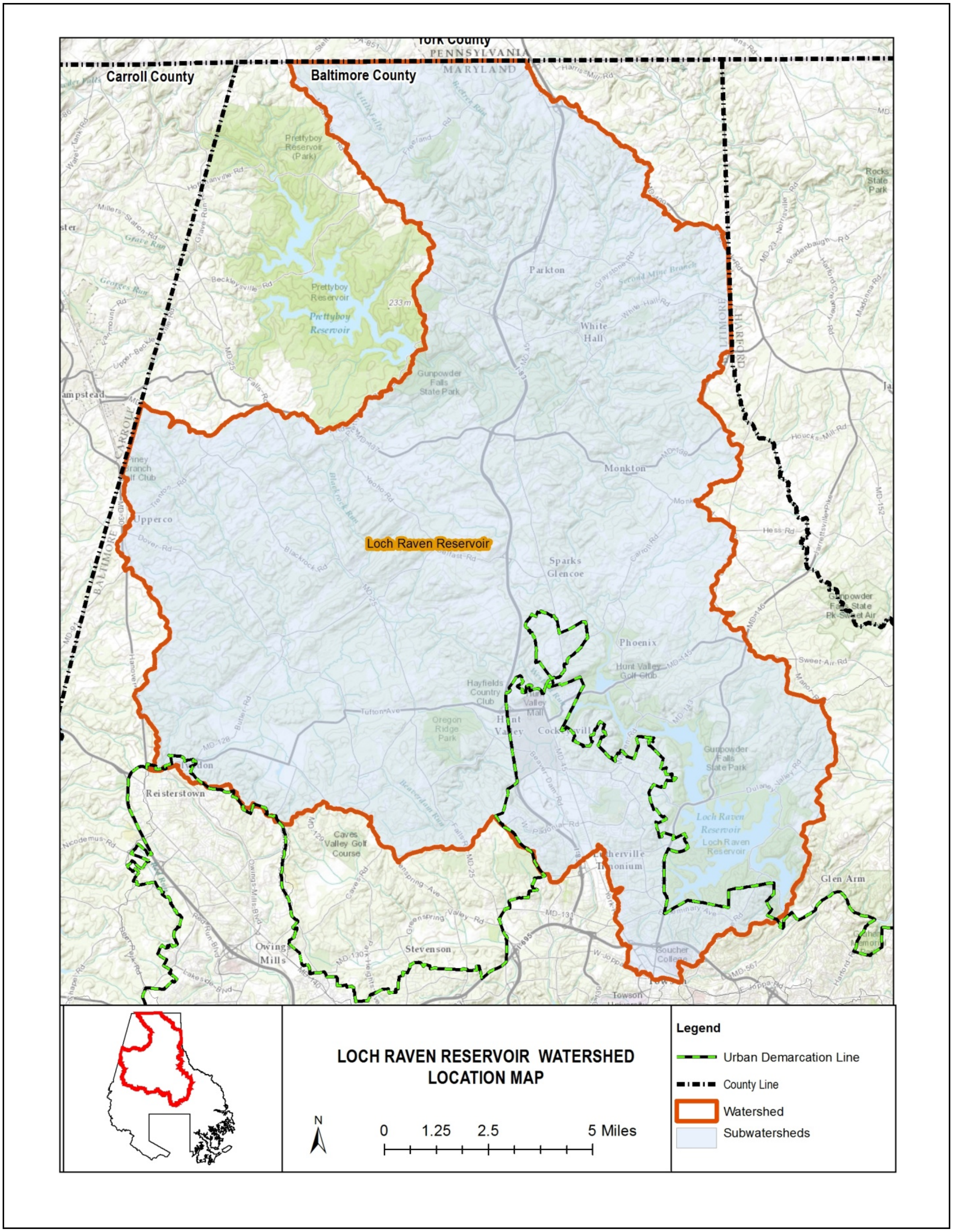

Figure 5.1: Loch Raven Reservoir Watershed

5.1.3 Streams

Streams were analyzed using Geographic Information Systems. 2005 Hydrology data was queried on "SINGLE LINE STREAM" and "DOUBLE LINE STREAMS/RIVERS". Double line streams data was divided by 2 and added to the single line stream data to calculate total stream miles. Table 5.2 shows length of streams in Loch Raven Reservoir.

Table 5.2: Streams Data for the Loch Raven Reservoir Watershed (Baltimore County)

Linear Feet of Stream	Miles of Stream
5,016,195.2	950.0

5.2 Land Use, Sediment Loads and Reductions

As mentioned above, 1997 is the baseline year for the sediment TMDL for the Loch Raven Reservoir watershed. The analyses completed on sediment loads and reductions, pre and post baseline, to determine the appropriate TMDL target are described below.

Due to the need to reconcile this plan with the Chesapeake Bay TMDL, a land use dataset was needed that had current data, and was also appropriate for analyzing change over time. A land use dataset was created to meet these requirements by fusing the USGS National Land Cover Database (Jin, 2013) from 2001, 2006, and 2011 with Baltimore County impervious surface data from 1995, 1996, 1997, 2001, 2005, and 2011. This land use dataset and the pollutant loading rates used for the analysis in this plan differ from the data used in the TMDL document, and therefore produced different results. Pollutant loading rates from the most recent Bay Model (5.3.2) were used to calculate the loads for this plan based on land use. This method is in congruence with the MDE reconciliation document method described in Section 3.

Table 5.3 shows the Loch Raven Reservoir sediment loads for the baseline and current broken out by all land uses. Loading rates used and shown in Table 5.3 are from the Chesapeake Bay Program's Watershed Model 5.3.2.

Table 5.3: Change In Loch Raven Reservoir Sediment Total Loads Based on Land Use (Baltimore County)

Land Use	SED Loading Rate (lbs/ac/yr)	Acres Baseline (1997)	SED Load Baseline (lbs/yr)	Acres Current (2011)	SED Load Current (lbs/yr)	Δ in acres (acres)	Δ in SED Load (lbs/yr)
Water	0.0	2,021.2	0.0	2,059.4	0.0	38.2	0.0
Urban Pervious	220.64	22,463.4	4,956,332.2	22,158.3	4,889,009.1	-305.1	-67,323.1
Urban Impervious	1,601.51	6,277.4	10,053,270.0	7,623.1	12,208,422.3	1,345.7	2,155,152.4
Extractive	2,966.60	423.3	1,255,775.7	447.3	1,326,982.4	24.0	71,206.7
Forest	64.36	64,142.3	4,128,200.3	63,605.4	4,093,646.6	-536.9	-34,553.7
Pasture	277.62	23,607.3	6,553,870.3	22,869.4	6,348,995.7	-738.0	-204,874.6
Crop	1,111.18	20,643.9	22,939,126.0	20,815.0	23,129,157.9	171.0	190,031.8
Total			49,886,574.5		51,996,214.0		**2,109,639.5**

Note that Table 5.3 demonstrates that there was a significant increase in urban impervious coupled with a decrease in forest, urban pervious and pasture. This resulted in an overall increase in the sediment load.

Some restoration has already taken place, both before and after the TMDL baseline year. Pre and post baseline restoration is shown in Tables 5.4 and 5.5 respectively.

Table 5.4: Loch Raven Reservoir Restoration Sediment Reductions in Baltimore County Before Baseline (1997)

Restoration Type	SED Reductions (lbs/yr)
Stormwater Management	521,566.8
Ba Co Restoration Projects	626,371.0
Watershed Group Buffer Plantings	0.0
Watershed Group Upland Plantings	0.0
Watershed Group Disconnections	0.0
Ba Co Rain Barrel Sales	0.0
Ba Co Tree Planting	0.0
Total Restoration Reductions	626,371
Total (lbs/yr)	**1,147,937.8**

Table 5.5: Loch Raven Reservoir Restoration Total Sediment Reductions (Baltimore County)

Restoration Type	SED Reductions (lbs/yr)
Stormwater Management	1,446,181.1
Ba Co Restoration Projects	1,052,527.9
Watershed Group Buffer Plantings	10,841.0
Watershed Group Upland Plantings	4,072.7
Watershed Group Disconnections	49.9
Ba Co Rain Barrel Sales	3,681.2
Ba Co Tree Planting	1,909.7
Total Restoration Reductions	1,073,082
Total (lbs/yr)	**2,519,263.5**

Baltimore County is charged with addressing pollutant loads from urban land. Table 5.6 shows only the urban land uses and their associated loads. Also shown in Table 5.6 are the restoration reductions prior to the baseline year and up to the current year from Tables 5.4 and 5.5. The total sediment load after these reductions are applied is also shown in Table 5.6.

Table 5.6: Change In Loch Raven Reservoir Sediment Urban Loads Based on Land Use (Baltimore County)

Land Use	SED Loading Rate (lbs/ac/yr)	Acres Baseline (1997)	SED Load Baseline (lbs/yr)	Acres Current (2011)	SED Load Current (lbs/yr)	Δ in SED Load Since Baseline
Urban Pervious	220.6	22,463.4	4,956,332.2	22,158.3	4,889,009.1	-67,323.1
Urban Impervious	1,601.5	6,277.4	10,053,270.0	7,623.1	12,208,422.3	2,155,152.4
Total		28,740.8	**15,009,602.2**	**29,781.4**	**17,097,431.4**	**2,087,829.3**
Development Stormwater Management			-521,566.8		-1,446,181.1	
Restoration Reductions			-626,371.0		-1,073,082.4	
Total Load (lbs/yr)			**13,861,664.4**		**14,578,167.9**	**716,503**
Total Load (tons/yr)			**6,930.8**		**7,289.1**	**358.3**

Section 8 of this report has more specific details on the restoration BMPs and how their reductions are calculated.

In order to determine the TMDL target load, the increase in the sediment load from the baseline year (1997) to the present day was calculated and is shown in Table 5.6 (716,503 pounds/yr).

The percent reduction required to meet the TMDL for Baltimore County urban land is 0% from the baseline load (MDE, MDE TMDL Data Center WLA Search, 2014). However, since the baseline year, the total sediment load in the watershed has increased due to changes in land use. This increase in load (716,503/yr) was added to the reduction required from the baseline load (0.0 tons/yr) to obtain the total sediemnt reduction required (716,503 pounds/yr). There is an assumption of a 25% sediment reduction achieved when a 50% phosphorus reduction is met. Table 5.7 shows the 25% load reduction assumption and the load increase along with other data from the calculations used to determine the total reduction required to meet the TMDL.

Table 5.7: Sediment Reduction Required to meet TMDL (Baltimore County Urban Land)

Baseline SED Load (pounds)	Current SED Load (pounds)	% Reduction Required From Baseline*	SED Reduction Required From Baseline (pounds/yr)	Increase in SED Load From Baseline (pounds/yr)	Total SED Reduction Required (pounds/yr)
13,861,644	7,289.1	25	3,465,411	716,503	**4,181,914**

* There is no required percentage reduction from the urban stormwater sector. There is an assumption of a 25% reduction associated with the 50% phosphorus reduction

In order to meet the requirements of the TMDL, BMPs must be installed to reduce 358.3 tons of sediment per year. Section 9 of this TMDL Implementation Plan details how Baltimore County can meet this urban allocation of the Loch Raven Reservoir sediment TMDL. Most BMPs have a cumulative effect, meaning a one-time installation results in pollutant reduction year after year for the life of the BMP.

Two ambient water quality monitoring programs provide sediment data for the Loch Raven watershed including monitoring done by Baltimore County and the Maryland Department of Natural Resources (DNR). DNR core/trend data is presented in Section 6.1 and Baltimore County trend data is presented in Section 6.2. Section 6.3 discussed Baltimore City monitoring data, which is not applicable because it was a baseflow sampling program. Section 6.4 examines the current condition of Loch Raven sediment using both sets of data. Section 6.5 Uses Baltimore City in-lake data to see if the TMDL water quality standard is being achieved. Baltimore County had a baseflow program but that data is not applicable to the TMDL. The baseflow program sampled dry weather flows only and this is representative of only a small part of the total suspended sediment load. Sites can be seen in Figure 6.1.

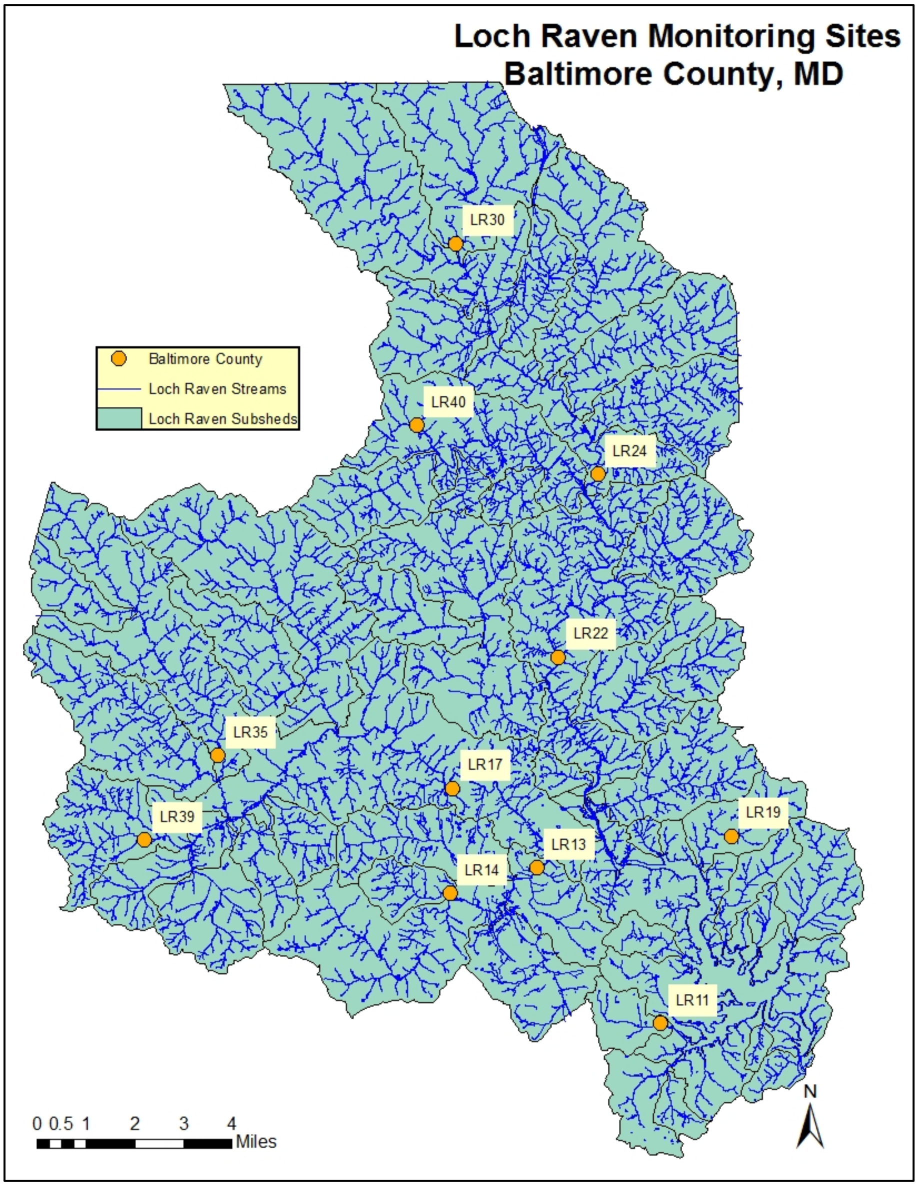

Figure 6.1: Chemical Monitoring Locations in Loch Raven Watershed

6.1 Core/Trend Program

DNR conducts an ambient fixed station water quality monitoring program (Core/Trend) to assess statewide water quality status and trends. The 54 sampling locations are distributed throughout the state, with particular attention to the Potomac River. One of the sites is located on the Gunpowder River.

Station GUN0258 is located on Gunpowder Falls at Glencoe Road; this is also Baltimore County trend site LR-22. USGS gage 01582500 is also at this location. The drainage area of this subshed is 102,240 acres. The USGS gage provides real-time flow data which is used in the load calculations. The gage data can be found at: http://waterdata.usgs.gov/usa/nwis/uv?01582500.

Samples are taken each month on a pre-determined date. Table 6-1 displays the yearly average flow in cubic feet per second and various phosphorus parameters from 2007 through 2013 in lbs/acre/day. Data from 1997 to 2006 are not included because the 15 minute interval data are not available for download from the USGS website. The chemical results from the core/trend monitoring were analyzed in conjunction with the discharge data. Both the chemical and the discharge data were $\log_{10}$ transformed before regression analysis. The regression equations were used to calculate the chemical concentrations for each 15 or 5-minute interval for recorded discharge (equation 6.1).

Equation 6.1: Pollutant Load Calculation

$P_L = (P_C x.000008345)x(CFSx448.8x1440)$,

Where,

P_L = Pollutant Load,
P_C = Pollutant Concentration,
.000008345 = Conversion factor to convert mg/L to pounds per gallon,
CFS = Cubic feet per second,
448.8 = Conversion factor to convert cubic feet per second to gallons per minute
1440 = number of minutes in one day

The result of the above equation is in lbs/day of pollutant, which can then be divided by the number of acres in the drainage area to derive the lbs/acre/day load. The flow is the average for the year of cfs at time of sampling.

6.1.1 Summary of Data Results

Water quality parameters measured as part of the core/trend monitoring program include Total Suspended Sediment (TSS). Chemical monitoring results collected for these sites are summarized in Table 6.1. The Loch Raven total suspended solids TMDL is set at 79.25 tons/day or 158,493 lbs/day. The loading rate can also be normalized by acre and expressed as 0.84 lbs/acre/day. By normalizing the loading rate by acres, a better comparison can be made between the sites monitored and the TMDL loading rate. The highest year, 2011, Tropical Storm Lee occurred. The data is graphically represented in Figure 6.2.

Table 6.1: Core/Trend Monitoring Results at Site GUN0258

Date	N	Average Daily Flow (cfs)	Annual TSS (lbs)	TSS (lbs/acre/day)
2007	7	134.8	2,059,865.5	0.055
2008	26	148.2	2,289,707.9	0.061
2009	30	206.8	3,475,533.9	0.093
2010	31	212.5	3,513,635.9	0.094
2011	32	256.3	4,427,529.8	0.119
2012	29	217.3	3,737,436.1	0.100
2013	27	216.6	3,578,310.8	0.096
average		230.1	3,914,425.6	0.105

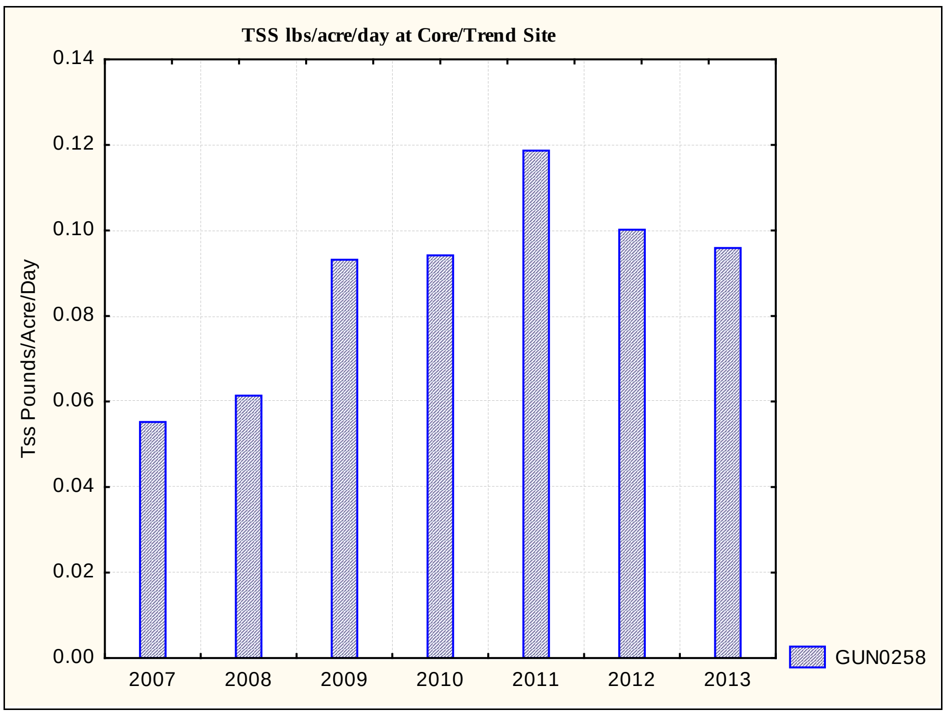

Figure 6.2: TSS lbs/acre/year at GUN0258

6.1.2 Comparison of Data to TMDL Targets

The TMDL target of 0.84 lbs/acre/day was reached at all sites for all years.

6.2 Baltimore County Data

In January 2011, Baltimore County's baseflow monitoring program was replaced with a water quality trend monitoring program. The trend monitoring program observes ambient chemical conditions and determines trends in chemical concentrations and pollutant loads over time at forty-one sites. This data is used to determine areas to target restoration, assess the impact of implemented restoration activities, and determine the amount of progress made towards meeting TMDLs and other restoration goals. The sites are broken into four sampling days which remain the same each month regardless of weather. Eleven of those trend sites were within the Loch Raven watershed (Figure 6.1):

1. LR11 (949 acres) which is located on Spring Branch at Dulaney Valley Road;
2. LR13 (13,372 acres) which is located on Beaver Dam Run at Beaver Run Lane;
3. LR14 (956 acres) which is located on Baismen Run at Ivy Hill Road;
4. LR17 (38,461 acres) which is located on Western Run at Western Run Road;
5. LR19 (1,117 acres) which is located on Overshot Run at Jarrettsville Pike;
6. LR22 (102,240 acres) which is located on Gunpowder Falls at Glencoe Road;
7. LR24 (34,391 acres) which is located on Little Falls at Bluemount Road;
8. LR30 (6,186 acres) which is located on Beetree Run at Bentley Road;
9. LR35 (7,873 acres) which is located on Piney Run at Butler Road;
10. LR39 (1,372 acres) which is located on Slade Run at Longnecker Road; and
11. LR40 (52,144 acres) which is located on Gunpowder Falls below Loch Raven at Falls Road.

6.2.1 Summary of Data Results

Water quality parameters measured as part of the County's trend monitoring program include Total Suspended Sediment (TSS). Trend chemical monitoring results collected for these sites are summarized in Table 6.3.

Table 6.3: Average Baltimore County Trend Sampling Results

Site	Date	N	Average Daily Flow (cfs)	Annual TSS (lbs)	TSS (lbs/acre/day)
LR13	2011	12	44.6	8,027,816.8	1.6448
LR13	2012	12	33.7	5,086,528.6	1.0422
LR13	2013	12	31.3	2,271,743.0	0.4654
average			36.5	5,128,696.1	1.0508
LR14	2011	11	1.8	4,799.4	0.0138
LR14	2012	12	1.7	4,523.0	0.0130
LR14	2013	12	1.9	4,878.9	0.0140
average			1.8	4,733.7	0.0136
LR17	2011	12	97.4	1,010,506.7	0.0720
LR17	2012	12	84.1	807,350.7	0.0575
LR17	2013	12	87.5	777,434.1	0.0554
average			89.7	865,097.2	0.0616
LR19	2011	12	2.0	5,424.1	0.0133
LR19	2012	12	1.9	5,120.6	0.0126
LR19	2013	12	2.1	5,542.5	0.0136
average			2.0	5,362.4	0.0132

Site	Date	N	Average Daily Flow (cfs)	Annual TSS (lbs)	TSS (lbs/acre/day)
LR22	2011	12	256.3	973,596.6	0.0261
LR22	2012	12	217.3	840,584.8	0.0225
LR22	2013	12	216.6	742,165.4	0.0199
average			230.1	852,115.6	0.0228
LR24	2011	7	100.8	1,210,063.3	0.0964
LR24	2012	12	71.5	748,013.5	0.0596
LR24	2013	12	75.6	698,884.6	0.0557
average			82.6	885,653.8	0.0706
LR30	2011	12	18.2	50,330.2	0.0223
LR30	2012	12	12.8	35,559.9	0.0157
LR30	2013	12	14.8	40,913.6	0.0181
average			15.3	42,267.9	0.0187
LR35	2011	12	18.8	2,794,982.8	0.9726
LR35	2012	12	18.2	1,351,396.2	0.4703
LR35	2013	12	17.2	1,416,562.0	0.4929
average			18.1	1,854,313.7	0.6453
LR39	2011	12	2.5	242,577.6	0.4844
LR39	2012	12	2.4	130,224.0	0.2600
LR39	2013	12	2.2	125,475.8	0.2506
average			2.4	166,092.5	0.3317
LR40	2011	12	146.2	663,267.6	0.0348
LR40	2012	12	108.0	396,425.5	0.0208
LR40	2013	12	106.7	372,750.8	0.0196
average			120.3	477,481.3	0.0251

Figure 6.3 graphically shows TSS lbs/acre/day at the eleven trend monitoring program sites over the years.

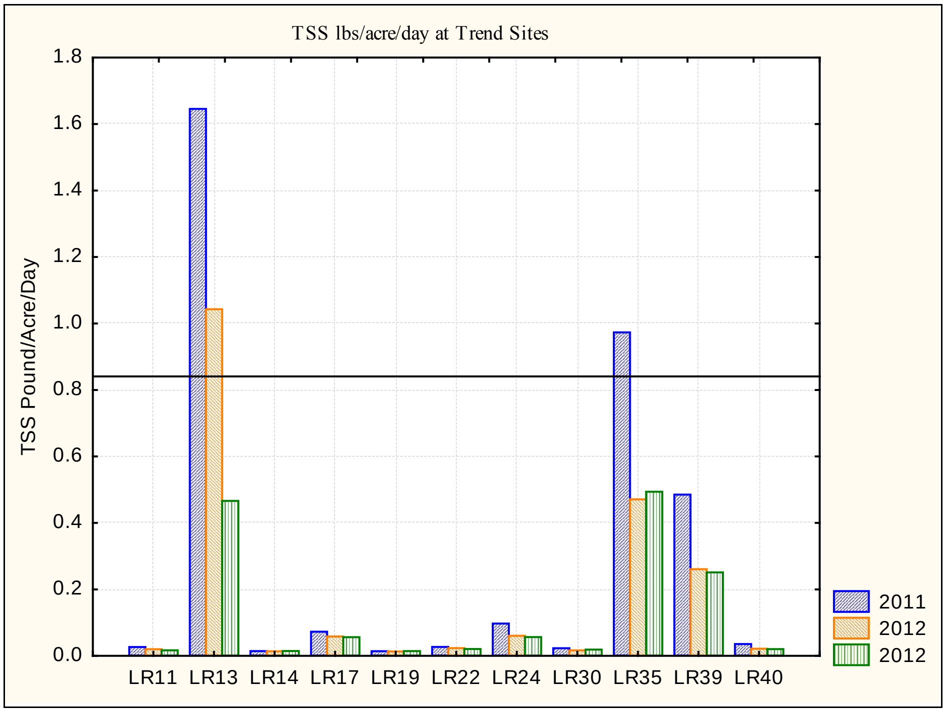

Figure 6.3: TSS lbs/acre/day at Baltimore County Trend Monitoring Sites

6.2.2 Comparison of Data to TMDL Targets

The TMDL target of 0.84 lbs/acre/day was reached at all but two sites: LR13 and LR35.

6.3 Baltimore City Data

The Baltimore City Department of Public Works conducts monitoring at seven sites in the Loch Raven Reservoir watershed. The tributary stream locations were monitored during dry-weather periods. Prior to 2013 the sampling program was for baseflow conditions. Starting in 2013, the monitoring was switched to fixed interval sampling. This data has been excluded from the analysis because only 2013 was trend. Five of the sampling sites correspond with Baltimore County trend sites.

6.4 Summary of Current Condition

There is currently one stream in Loch Raven Reservoir being monitored by multiple organizations. Table 6.4 is a summary of the two agencies' data. As can be seen in Table 6.6, almost all sites were under the loading rate almost all years sampled. Beaver Dam run was over the loading rate in 2011 and 2012 and Piney Run was over in 2011. Data for the site using combined data is graphically represented in Figure 6.4; this site is meeting the TMDL goal of 0.84 mg/L.

Table 6.4: Summary of Loch Raven Reservoir Monitoring (lbs/acre/day)

Site	Date	N	DNR Site Name	Baltimore County Site Name	Average Flow (cfs)	Annual TSS (lbs)	TSS (lbs/acre/ day)
Spring Branch	2011	12	n/a	LR11	1.7	8,948.3	0.0258
Spring Branch	2012	12	n/a	LR11	1.4	6,637.9	0.0192
Spring Branch	2013	12	n/a	LR11	1.3	5,519.2	0.0159
Average					1.4	7,035.2	0.0203
Beaver Dam Run	2011	12	n/a	LR13	44.6	8,027,816.8	1.6448
Beaver Dam Run	2012	12	n/a	LR13	33.7	5,086,528.6	1.0422
Beaver Dam Run	2013	12	n/a	LR13	31.3	2,271,743.0	0.4654
Average					36.5	5,128,696.1	1.0508
Baisman Run	2011	11	n/a	LR14	1.81	4,799.4	0.0138
Baisman Run	2012	12	n/a	LR14	1.75	4,523.0	0.0130
Baisman Run	2013	12	n/a	LR14	1.89	4,878.9	0.0140
Average					1.89	4,733.7	0.0136
Western Run	2011	12	n/a	LR17	97.4	1,010,506.7	0.0720
Western Run	2012	12	n/a	LR17	84.1	807,350.7	0.0575
Western Run	2013	12	n/a	LR17	87.5	777,434.1	0.0554
Average					89.7	865,097.2	0.0616
Overshot Run	2011	12	n/a	LR19	2.0	5,424.1	0.0133
Overshot Run	2012	12	n/a	LR19	1.9	5,120.6	0.0126
Overshot Run	2013	12	n/a	LR19	2.1	5,542.5	0.0136
Average					2.0	5,362.4	0.0132
Gunpowder Falls- Glencoe Rd.	2007	26	GUN0258	LR22	134.79	1,553,601.7	0.0416
Gunpowder Falls- Glencoe Rd.	2008	26	GUN0258	LR22	148.16	1,718,387.8	0.0460
Gunpowder Falls- Glencoe Rd.	2009	32	GUN0258	LR22	206.76	2,518,632.2	0.0675
Gunpowder Falls- Glencoe Rd.	2010	32	GUN0258	LR22	212.46	2,566,746.6	0.0688
Gunpowder Falls- Glencoe Rd.	2011	46	GUN0258	LR22	256.26	3,174,473.2	0.0851
Gunpowder Falls- Glencoe Rd.	2012	36	GUN0258	LR22	217.35	2,678,737.5	0.0718
Gunpowder Falls- Glencoe Rd.	2013	31	GUN0258	LR22	216.57	2,614,597.2	0.0701
Average					228.69	2,806,652.4	0.0752
Little Falls	2011	7	n/a	LR24	100.8	1,210,063.3	0.0964
Little Falls	2012	12	n/a	LR24	71.5	748,013.5	0.0596
Little Falls	2013	12	n/a	LR24	75.6	698,884.6	0.0557
Average					82.6	885,653.8	0.0706

Site	Date	N	DNR Site Name	Baltimore County Site Name	Average Flow (cfs)	Annual TSS (lbs)	TSS (lbs/acre/ day)
Beetree Run	2011	12	n/a	LR30	18.2	50,330.2	0.0223
Beetree Run	2012	12	n/a	LR30	12.8	35,559.9	0.0157
Beetree Run	2013	12	n/a	LR30	14.8	40,913.6	0.0181
Average					15.3	42,267.9	0.0187
Piney Run	2011	12	n/a	LR35	18.8	2,794,982.8	0.9726
Piney Run	2012	12	n/a	LR35	18.2	1,351,396.2	0.4703
Piney Run	2013	12	n/a	LR35	17.2	1,416,562.0	0.4929
Average					18.1	1,854,313.7	0.6453
Slade Run	2011	12	n/a	LR39	2.5	242,577.6	0.4844
Slade Run	2012	12	n/a	LR39	2.4	130,224.0	0.2600
Slade Run	2013	12	n/a	LR39	2.2	125,475.8	0.2506
Average					2.4	166,092.5	0.3317
Gunpowder Falls- Falls Road	2011	12	n/a	LR40	146.2	663,267.6	0.0348
Gunpowder Falls- Falls Road	2012	12	n/a	LR40	108.0	396,425.5	0.0208
Gunpowder Falls- Falls Road	2013	12	n/a	LR40	106.7	372,750.8	0.0196
Average					120.3	477,481.3	0.0251

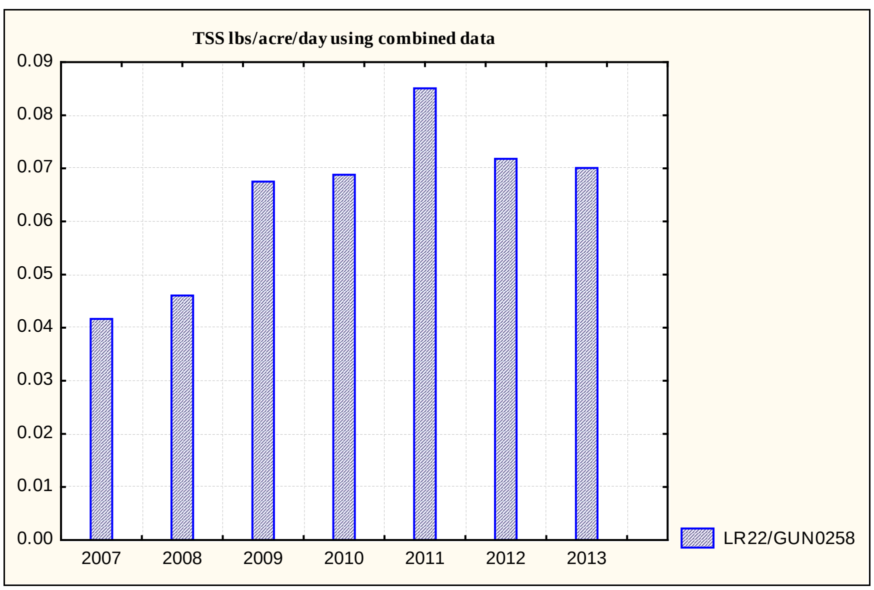

Figure 6.4: TSS lbs/acre/day using combined data

6.5 Comparison of Data to TMDL Water Quality Standard: Chlorophyll a (Chl a)

Eutrophic lakes have high algal production and in severe condition can cause drinking water treatment problems as well as taste and odor issues. The degree of eutrophication is measured by the amount of chlorophyll *a*, the concentration of phosphorus, and water turbidity. MDE used Chl *a*, a measure of algal biomass, as the water quality endpoint for the phosphorus TMDL. The Chl *a* endpoints selected for the Loch Raven Reservoir a 30-day moving average concentration not to exceed 10 µg/L in the surface layers. A chlorophyll *a* value of 10 µg/l corresponds to the boundary between mesotrophic (moderately impaired) and eutrophic conditions.

The Baltimore City Department of Public Works conducts monitoring at three in-lake sites in the Loch Raven Reservoir (Figure 6.1):

1. GUN0142 which is located at the Loch Raven Gatehouse;
2. GUN0156 which is located Loch Raven Drive Bridge;
3. GUN0171 which is located on Loch Raven between Picnic & Golf Course Areas;
4. GUN0174 which is located at Dulaney Valley Rd. Bridge; and
5. GUN0190 which is located on Loch Raven at Powerlines.

Figure 6.5 shows the Chl *a* µg/L for all three sites combined, these include the 0, 10 feet, and 20 feet data. The 20 foot depth is used by Baltimore City as the boundary of the epiliminion. Data is included only for the growing season when water is warmer, April 1 to September 30. The data was combined to increase N for each sampling day. N is the number of samples used in the calculations. All sites were not sampled every month, every year; in the current data set combining all five sites gives most sampling dates the largest N of 9. All sampling periods for each year did not start on the same day and some had more 30 day sampling periods than others.

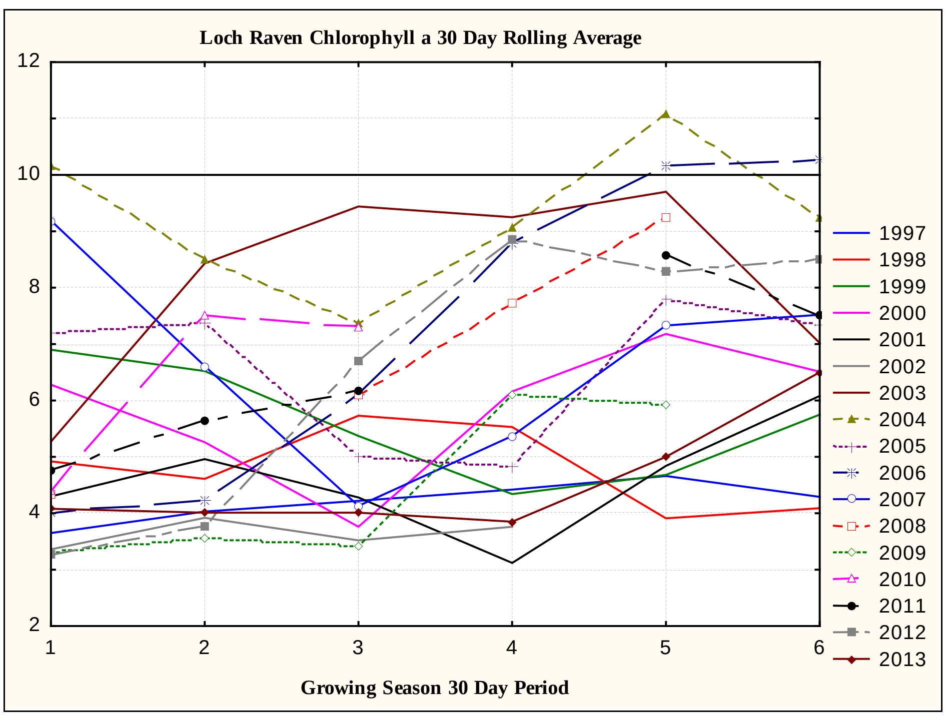

Figure 6.5: Average in-lake Chlorophyll a 30 Day Rolling Average at Loch Raven Reservoir

Raw data can be found in Appendix 6.5. Figure 6.5 shows the 30 day rolling average using data from the five in-lake monitoring sites. The water quality target was missed four times, twice in 2004 and twice in 2006. Figure 6.7 shows the days that were over the water quality goal of 10 µg/l. However, the water quality goal is based on a 30 day rolling average and not a daily average.

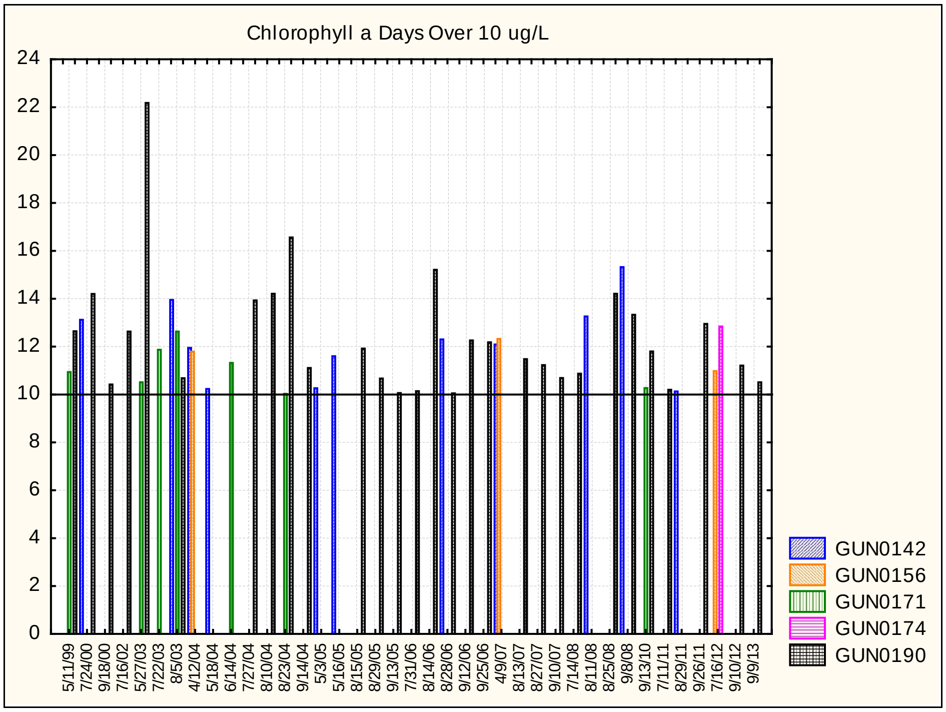

Figure 6.6: Chlorophyll a Days over 10 µg/l Loch Raven Reservoir

Baltimore County has completed a series of Water Quality Management Plans (WQMPs) and Small Watershed Action Plans (SWAPs) throughout the county. These past studies were used to inform the TMDL Implementation Plans, as applicable. All completed SWAP documents and their appendices are available online.

7.1 Water Quality Management Plan for Loch Raven Watershed

The WQMP for Loch Raven is a document that details potential Capital Improvement Projects (CIPs) that the county could consider to improve water quality. These Management Plans focused on county-specific actions, and not citizen-based initiatives. The plans outlined in the WQMP may be useful for determining CIPs that the county may still implement through this plan and in the future, however the WQMP does not have a water quality end point target.

7.2 Loch Raven Reservoir, Small Watershed Action Plans (SWAPs)

The Loch Raven Reservoir watershed, for purposes of SWAP development, was divided into five distinct planning areas due to the size of the watershed and the variation in land use. Two SWAPs are complete, two are in progress, and one has not been initiated (see Table 7.1).

Table 7.1 Status of Loch Raven Watershed SWAPs

SWAP Area Name	Status of SWAP
Beaverdam Run, Oregon Branch, and Baisman Run	Completed, 2011
Loch Raven East	Completed, 2014
Loch Raven North	In progress
Loch Raven South	In progress
Loch Raven West	Planned for 2016

These documents present strategies and provide guidance for restoration of their respective portions of the watershed, and identify priority projects for implementation. SWAPs delineate multiple subwatersheds within each planning area. Each subwatershed area receives a focused review and assessment, and a customized restoration plan. Neighborhoods, institutional facilities, and potential pollution hot-spots are then identified within the subwatersheds and individually assessed by multiple field crews to develop strategies for pollution reduction in each area.

The SWAP is a strategy for restoring a particular watershed, or portion of a watershed. The two completed SWAPs for Loch Raven were completed in 2011 and 2014, by Baltimore County Department of Environmental Protection and Sustainability with extensive input from county citizens, county and state agencies, members of local watershed associations, Baltimore County Soil Conservation District, and various local institutions. The reports include recommendations for watershed restoration, describe management strategies for each of the subwatersheds within the SWAP areas, and identify priority projects for implementation. The SWAP includes a list of potential capital projects, citizen based restoration opportunities, and operational program implementation. The plan also provides cost-estimates for projects and a schedule for implementation. Financial and technical partners are suggested for certain projects. Many action items listed in the SWAPs have already been evaluated for feasibility and can easily be translated into measurable load reductions. SWAPs include local based goals and objectives that are beyond the scope of the TMDL Implementation Plan.

Section 8 - Best Management Practice Efficiencies

This best management practice (BMP) efficiencies section will provide basic information on each BMP capable of reducing sediment in the Loch Raven Reservoir watershed and approved as such by the Chesapeake Bay Program (CBP).

Pollutant reducing capabilities of BMPs are often updated based on the findings of the CBP Urban Stormwater Workgroups (USW). Maryland Department of the Environment (MDE) provides a guidance document (MDE, Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated 2011) detailing acceptable reduction rates and calculations for BMPs. BMP efficiencies will be updated as newer rates and methods are approved by the USW and MDE.

8.1 BMP Descriptions

This section provides an overview of pollutant reduction measures and their predicted effectiveness. This overview is meant to serve as a guide to aid in selecting the most efficient possible BMPs that may be implemented to meet the pollutant reduction goals required by the TMDL. This review utilizes conservative estimates of BMP efficiency for planning purposes, as exact types of BMPs (e.g. structural BMPs) will not be chosen until appropriate on-site analysis is complete. It is possible that only some of the listed actions in this section will be selected for inclusion in Section 9 of this Implementation Plan.

Most definitions were obtained from the Excel sheet *BmpDefinitions 5_15_2014.xlsx* from the MAST website: http://www.mastonline.org/Documentation.aspx (D. E. MDE 2014).

Dry Detention Ponds – Dry Detention Ponds are depressions or basins created by excavation or berm construction that temporarily store runoff and release it slowly via surface flow or groundwater infiltration following storms.

Hydrodynamic Structures - Hydrodynamic Structures are devices designed to improve quality of stormwater using features such as swirl concentrators, grit chambers, oil barriers, baffles, micropools, and absorbent pads that are designed to remove sediments, nutrients, metals, organic chemicals, or oil and grease from urban runoff.

Dry Extended Detention Ponds – Dry extended detention (ED) basins are depressions created by excavation or berm construction that temporarily store runoff and release it slowly via surface flow or groundwater infiltration following storms. Dry ED basins are designed to dry out between storm events, in contrast with wet ponds, which contain standing water permanently. As such, they are similar in construction and function to dry detention basins, except that the duration of detention of stormwater is designed to be longer, theoretically improving treatment effectiveness.

Wet Ponds and Wetlands – A water impoundment structure that intercepts stormwater runoff then releases it to an open water system at a specified flow rate. These structures retain a permanent pool and usually have retention times sufficient to allow settlement of some portion of the intercepted sediments and attached nutrients/toxics. Until recently, these practices were designed specifically to meet water quantity, not water quality objectives. There is little or no vegetation living within the pooled area nor are outfalls directed through vegetated areas prior to open water release. Nitrogen reduction is minimal.

Infiltration Practices – A depression to form an infiltration basin where sediment is trapped and water infiltrates the soil. No underdrains are associated with infiltration practices, because by definition these systems provide complete infiltration. Design specifications require infiltration basins and trenches to be build in good soil, they are not constructed on poor soils, such as C and D soil types. Engineers are required to test the soil before approved to build is issued. To receive credit over the longer term, jurisdictions must conduct yearly inspections to determine if the basin or trench is still infiltrating runoff.

Filtering Practices – Practices that capture and temporarily store runoff and pass it through a filter bed of either sand or an organic media. There are various sand filter designs, such as above ground, below ground, perimeter, etc. An organic media filter uses another medium besides sand to enhance pollutant removal for many compounds due to the increased action exchange capacity achieved by increasing the organic matter. These systems require inspection and maintenance to receive pollutant reduction credit (Collins, et al. 2009).

Environmental Site Design – Using small-scale stormwater management practices, nonstructural techniques, and better site planning to mimic natural hydrologic runoff characteristics and minimize the impact of land development on water resources (MDE, 2000 Maryland Stormwater Design Manual 2000).

Street Sweeping and Inlet Cleaning – Street sweeping measured by the weight of street residue collected. Street sweeping and storm drain cleanout practices rank among the oldest practices used by communities for a variety of purposes to provide a clean and healthy environment, and more recently to comply with their National Pollutant Discharge Elimination System stormwater permits.

Tree Planting – Tree planting includes any tree planting, except those used to establish riparian forest buffers.

Urban Forest Buffers - An area of trees at least 35 feet wide on one side of a stream, usually accompanied by trees, shrubs and other vegetation that is adjacent to a body of water. The riparian area is managed to maintain the integrity of stream channels and shorelines, to reduce the impacts of upland sources of pollution by trapping, filtering, and converting sediments, nutrients, and other chemicals.

Impervious Surface Removal - Reducing impervious surfaces to promote infiltration and percolation of runoff storm water.

Stream Restoration - Stream restoration in urban areas is used to restore the urban stream ecosystem by restoring the natural hydrology and landscape of a stream, help improve habitat and water quality conditions in degraded streams.

Urban Nutrient Management-MD Fertilizer Use Act of 2011 - The State of Maryland passed the Maryland Fertilizer Use Act of 2011 that took effect in October 2013. The Act bans sediment and provides a greater percentage of slow release nitrogen in fertilizer.

Table 8.1 displays different types of BMPs and which pollutants they address. Some BMPs are able to address many different pollutants, while some BMPs may be specifically targeted at reducing only a few pollutants.

Table 8.1: Pollutant Reductions of BMPs

Practice	Nitrogen	Sediment	Sediment	Bacteria
Dry Detention Ponds and Hydrodynamic Structures	✓	✓	✓	✓
Dry Extended Detention Ponds	✓	✓	✓	✓
Wet Ponds & Wetlands	✓	✓	✓	✓
Infiltration Practices	✓	✓	✓	✓
Filtering Practices	✓	✓	✓	✓
Environmental Site Design	✓	✓	✓	
Street Sweeping and Inlet Cleaning	✓	✓	✓	✓
Tree Planting	✓	✓	✓	
Urban Forest Buffers	✓	✓	✓	✓
Impervious Surface Removal	✓	✓	✓	
Stream Restoration	✓	✓	✓	✓
MD Fertilizer Use Act of 2011	✓	✓		

Table 8.2 shows how the BMP practices listed above are credited.

Table 8.2: Sediment Reduction Efficiencies of BMPs

Practice	How Credited	Efficiency
Dry Detention Ponds and Hydrodynamic Structures	Reduction Efficiency	10%
Dry Extended Detention Ponds	Reduction Efficiency	60%
Wet Ponds & Wetlands	Reduction Efficiency	60%
Infiltration Practices	Reduction Efficiency	95%
Filtering Practices	Reduction Efficiency	80%
Environmental Site Design	Reduction Efficiency	90%
Street Sweeping and Inlet Cleaning	Load reduction (lbs) / ton of dry material	600
Tree Planting	Land use change	NA
Urban Forest Buffers	Efficiency + Land use change	50%
Impervious Surface Removal	Land use change	NA
Stream Restoration	Load reduction (lbs)/length (linear ft)	43.4
MD Fertilizer Use Act of 2011	NA	NA

8.2 BMP Calculations

Below is a description of the different types of reduction calculations used to estimate the amount of sediment removed by a BMP.

8.2.1 Reduction Efficiency Calculations

Pollutant reductions for practices with approved reduction efficiencies are calculated based on the approximate pollutant load received from the drainage area (DA) and removal efficiencies (RE) recommended by CBP for the various types of SWM faculties. The equation used to estimate sediment load reductions for a particular type of BMP is expressed as:

$$[LR\ (lbs/ac/yr)*DA\ (acres)]*RE\ (\%)$$

The pollutant load received from the drainage area contributing to the SWM facility is denoted by the first expression in brackets in the above equations. The load must be calculated for each type of land use draining to the facility using the appropriate loading rate (LR). The percent pollutant removal efficiency depends on the type of facility and is based on the values shown in Table 8.2.

8.2.2 Land Use Change Calculations

Pollutant reductions for practices like tree planting and impervious surface removal use a land use change calculation to estimate pollutant reductions. The equation used to estimate sediment load reductions for the land use conversion portion of stream buffer reforestation is expressed as:

Land Use Conversion = [LR1 (lbs/ac/yr) – LR2 (lbs/ac/yr)] Area (acres)*

Pervious area reforestation, for example, would involve converting an open pervious area land use to forest. Therefore, the loading rate would be reduced by a factor equal to the difference between pervious urban (LR1) and forest (LR2) loading rates used in the watershed pollutant analysis as shown in the first expression in brackets in the equations above. The approximate reduction in pollutant load would then be the reduced loading rate multiplied by the open pervious area available for reforestation.

8.3 Uncertainty and Research Needs

8.3.1 BMP Efficiency Uncertainty

Best management practices approved by the Chesapeake Bay Program are assigned estimated pollutant reducing capabilities based on the best available science at the time. Although every effort is made to be as accurate as possible with these estimates, uncertainties do exist surrounding the pollutant reducing capabilities of all BMPs. Differences in installation techniques, climate, maintenance practices and variability in research results can all affect the actual measurable pollutant reductions of BMPs. There is uncertainty surrounding land use change BMPs due to uncertainty in land use loading rates. (Simpson 2013)

8.3.2 Lag Times

It is important to understand the role of lag times in watershed management and planning. Lag time is the delay from when a pollution control action is taken to when it actually results in water quality improvements. It is the sum of time required for practices to take desired effect, time required for effect to be delivered to the water source, and time required for the waterbody to respond to the effect (Meals, Dressing, & Davenport, 2010). Lag times will vary depending on the watershed, the management action and the pollutant type. According to the Chesapeake Bay STAC Program Report from 2012, the lag time for sediment from source to stream in the Chesapeake Bay region is less than 1-5 years, but he lag time for sediment transport from stream to Bay is 5-100 years (Chesapeake Bay Program 2012). The report also states approximate lag times for various sediment reduction actions. The lag time for an urban sediment pond was reported to be approximately 1-3 years, while the lag time for a riparian forest was approximated at 2-10 years (Chesapeake Bay Program 2012). Given this data, it is reasonable to assume that in-stream reduction will not necessarily be measurable by 2025 when all actions will be implemented. What this means is that Baltimore County may implement all of the necessary measures to meet the TMDL reductions by 2025, as TMDL is actually a limit on the amount of pollutant that is allowed to enter the stream from upland sources, but measureable in-stream effects on water quality may take a decade or more to fully reflect the load reductions. Expectations for water quality improvement should be reasonably based on the effects of lag time.

In this section you will find a list of actions that together become one scenario as to how the county could reach the pollutant load target. While EPS has developed this scenario, progress will be assessed on an annual basis through results of implementation actions and monitoring data. It is intended that the Implementation Plan (IP) will be reviewed on a five-year cycle for potential revisions. The County takes an adaptive management approach to all watershed planning efforts.

Adaptive management is a decision process that promotes flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood (U.S. Department of the Interior 2009). The tools that Baltimore County will use in adaptive management are the tracking of implementation progress, identification of barriers that prevent targeted actions from occurring, and an enhanced monitoring program to measure progress in both reductions and meeting water quality standards. While this will be an on-going process, there will be a formal review of the strategy at five year intervals to determine if changes are needed or if the strategies are on track.

This section describes, specifically, what steps Baltimore County will take to reach its TMDL targets. The actions are broken out by programmatic actions, management actions, and restoration actions. The list of actions is followed by a summary of calculations, which shows how the reductions associated with the actions stacks up against the TMDL target. Finally, there is a discussion of the reductions, which includes a time frame indicating when the reduction load will be met and describes other factors that play into meeting the water quality criteria.

9.1 Implementation Actions

Programmatic actions are those that do not directly result in load reductions, but create the necessary conditions for load reduction, as shown in Table 9.1. Actions within this category might include public education and outreach activities, monitoring, or supporting specific legislation. These actions will move Baltimore County closer to achieving TMDL targets; however, there is currently no way to attribute a predictable pollutant load reduction to programmatic actions. Some programmatic actions, such as investigation and monitoring, are necessary to implement management and restoration actions or make those actions more efficient. Other programmatic actions, such as education and outreach actions, are predicted to increase the load reduction over time through BMP implementation by individual citizens. The exact load reduction is not predictable because the participation rate for individual home owners installing BMPs, as a result of public education, is not yet known. Educated citizens may support load reductions in other ways such as educating other citizens about watershed management actions, supporting legislation that improves watershed management, and other actions that do not have associated load reductions but support the necessary condition for pollutant reduction.

Management actions are those where there is regular management of county property, such as, street sweeping. It does not include the development of new control measures, such as, retrofitting highway yards. Management actions have predictable load reductions, which can be used to calculate the contribution of each action toward meeting the overall load reduction required by the TMDL.

In the case of local phosphorus/nutrient and sediment TMDLs in Baltimore County, the implementation horizon is dictated by the Chesapeake Bay TMDL. This results in a condensed timeframe to correspond to the implementation deadline for the bay TMDL. All actions determined to be needed to achieve the bay TMDL must be implemented by 2025. This does not mean that the TMDL end points will be met that year, however the BMPs must be in place by then. Therefore, all actions indicated for this TMDL also need to be implemented by 2025, a 10-year timeframe.

Baltimore County EPS is responsible for implementing all urban actions. The Baltimore County Soil Conservation District is responsible for implementing all agricultural actions.

In order to more comprehensively address required pollutant reductions in Baltimore County, the county will convene an Ag – TMDL Workgroup. This workgroup will be composed of local farmers, and representatives from the Baltimore County Farm Bureau, Maryland Agricultural Resource Council, Soil Conservation District, Maryland Department of Agriculture, Maryland Extension Service, USDA's Natural Resource Conservation Service, in conjunction with EPS.

Table 9.1: Implementation Actions

Action	Timeframe	Performance Standard	Responsible Party
Programmatic			
Convene an Ag – TMDL Workgroup	Within 1 year, then on-going	Establish workgroup and meet	EPS, BCSCD
Continuing Public Outreach Plan	On-going	Hold meetings with agencies, watershed groups, businesses, and public	EPS, GVC
Management			
Conduct street sweeping (2x historic rate)	On-going	Pounds collected; miles of streets swept	DPW
Conduct inlet cleaning (historic rate)	On-going	Pounds of material removed	DPW
Monitoring			
Continue Chemical Trend Monitoring program	On-going	Annual analysis/ report of data	EPS
Participate in the Reservoir Technical Group monitoring program (periodic tributary monitoring)	On-going	Annual analysis/ report of data	EPS, RTG
Work with Baltimore City to conduct periodic bathymetric surveys	Periodic	Analysis report including rate of infill	EPS, Baltimore City
Reporting			
Loch Raven SWAPs Implementation Committees to meet on a semi-annual basis to discuss implementation progress and assess any changes needed to meet the goals	20 years	2 meetings per year	EPS and Implementation Committee partners
Continue to update status of restoration projects and BMPs in the Annual MS4 Report	Annually	MS4 Report submitted to MDE and posted on county website	EPS
Implement the Continuing Public Outreach Plan	On-going	Number of actions per year	EPS
Hold Biennial State of Our Watersheds Conference in even years	Biennially	Conference held	EPS

Action	Timeframe	Performance Standard	Responsible Party
Adaptive management assessment of the Implementation Plan	5 year interval	Assessment complete	EPS

BCSCD = Baltimore County Soil Conservation District
DPW = Baltimore County Department of Public Works
EPS = Baltimore County Department of Environmental Protection and Sustainability
GVC = Gunpowder Valley Conservancy
RTG = Reservoir Technical Group

9.2 Restoration Actions

Restoration actions include the development of new control measures aimed to reduce pollutant loads as well as retrofits of existing stormwater management facilities. It may include reforestation actions as well as any stormwater control measures that do not require regular management on county property. Restoration actions will have predictable load reductions, which will be used to calculate the contribution of each action toward meeting the overall load reduction required by the TMDL.

Table 9.2 lists the types of restoration actions identified, amount of area to be addressed, and associated pollutant reduction for each practice. Most of the restoration action information comes from the two completed Loch Raven Reservoir SWAPs. Keeping in mind that there are three other SWAPs yet to be completed, additional amounts were included for some of the restoration types. Table 9.3 summarizes the pollutant reductions anticipated from implementation of the actions.

Table 9.2: Restoration and Management Actions

Action	**Units**	**Total**	**Load Reduction (lbs/year)**
Stream Restoration	Linear feet	13,700	614,856
SWM Conversions	Acres	600	215,843
Retrofits	Acres	500	212,573
Riparian Buffer Reforestation	Acres	10	4,213
Upland Reforestation	Acres	50	7,814
Tree Canopy Planting	# Trees	700	1,094
Street Sweeping	Pounds	Historic Rate	99,222
Inlet Cleaning	Pounds	Historic Rate	1,340
Redevelopment	Acres	100	112,106
Total Reduction			**1,182,912**

Table 9.3: Load Reduction Calculations

Urban TSS Load Reduction Goal to Meet TMDL (lbs/year)	**716,600**
Total TSS Reduction Achieved By Proposed Future Actions (lbs/year)	**1,182912**

The actions proposed will meet the phosphorus TMDL urban stormwater reduction requirements. While the action will not meet a 25% reduction of the sediment baseline (3,465,411), they will meet and exceed the reductions for the increase in the baseline load due to development during the development of the TMDL and the development of the implementation plan. The TMDL allocated 0% reduction in sediment from the urban stormwater sector, but we must address any increase over the cap.

More details on pollutant loads and reductions can be found in Section 5.2.

9.3 Reductions Discussed

The timeline to implement all of the future actions extends over the next 10 years. That means that all actions will be implemented by 2025, however it is important to understand the role of lag times in watershed management and planning. Lag time is the delay from when a pollution control action is taken to when it actually results in water quality improvements. It is the sum of time required for practices to take desired effect, time required for effect to be delivered to the water source, and time required for the water body to respond to the effect (Meals, Dressing, & Davenport, 2010). Lag times will vary depending on the watershed, the management action and the pollutant type.

What this means is that Baltimore County may implement all of the necessary measures to meet the TMDL reductions by 2025, as the TMDL is actually a limit on the amount of pollutant that is allowed to enter the stream from upland sources, but measureable effects on water quality in the reservoir may take a decade or more to fully reflect the load reductions. Expectations for water quality improvement should be reasonably based on the effects of lag time.

Additionally, Baltimore County watersheds receive input from other municipal jurisdictions. Ultimately, Baltimore County strives to meet all of its TMDL requirements; however, inputs from other jurisdictions are not reduced as a result of Baltimore County reaching its TMDL targets. All inputs to the watershed will contribute to the make-up of the aquatic community and will ultimately affect measures of water quality.

Reductions associated with the restoration actions included in Table 9.2 exceed the target reduction for sediment in the Loch Raven watershed by over 650,000 lbs/year. Since the same best management practices will be employed for reduction of phosphorus, the restoration quantities will remain as such. It appears that the target for sediment reduction will be met more readily than that of phosphorus reduction.

The assessment of implementation progress is based on two aspects; progress in meeting programmatic, management, and restoration actions; and progress in meeting water quality standards and any interim water quality benchmarks. The assessment of progress in meeting the restoration actions includes; setting up methods of data tracking, validation of projects, and pollutant load reductions associated with the actions (10.1) and will be consistent across all TMDL Implementation Plans. The assessment of progress in meeting water quality standards and interim milestones (10.2) is based on the data analysis associated with the monitoring plan specific to each TMDL Implementation Plan.

10.1 Implementation Progress: Data Tracking, Validation, Load Reduction Calculation, and Reporting

The Baltimore County Department of Environmental Protection and Sustainability – Watershed Management and Monitoring Section is currently preparing a document entitled *Baltimore County Method for Pollutant Load Calculations, Pollutant Load Reduction Calculations, and Impervious Area Treated*. This document will detail the data sources, data analysis (including pollutant load calculations, and pollutant load reductions calculations), validation of the practices, and reporting of progress made. It was determined that a document was needed to keep a record how Baltimore County calculated pollutant loads and pollutant load reductions from the implementation of various best management practices, as guidance from the state and Chesapeake Bay Program continue to evolve. The document will be updated annually to account for any changes that may have occurred during the previous year. Due to the fact that implementation is being achieved through the actions of many county agencies, it was also determined that the means of data acquisition, any data manipulation, and the means of data analysis needs to be documented on an annual basis to provide consistency and track changes in the process over time. The overall result is intended to provide transparency for the general public and users of reports.

The Maryland Department of the Environment (MDE) has provided a guidance document for NPDES – MS4 permits entitled: *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated*. The draft document was released in June 2011, followed by a final release in August 2014. The document is intended to provide consistency among the MS4 jurisdictions in calculating baselines and reporting implementation progress. The August 2014 edition includes the Chesapeake Bay Program (CBP) recent recommendations for nutrient and sediment reductions for various practices. It is anticipated that the document will be updated on a periodic basis to reflect new information on restoration practice efficiencies in pollutant load reductions. MDE also provides guidance through its web site, with a webpage entitled *Maryland TMDL Data Center*. This site provides guidance on the development of the TMDL Implementation Plans and is updated on a regular basis.

The Chesapeake Bay Program (CBP) has developed a process whereby through the formation of Expert Panels, the scientific literature is reviewed to determine pollutant load reductions for various types of restoration practices. The Expert Panels provide reports on the load reduction calculations for the various practices, along with supporting documentation; these reports are then reviewed by a series of CBP workgroups and when approved, become the basis for pollutant load reduction credits. The completed documents are posted on the web along with a description of the process, see: <http://stat.chesapeakebay.net/?q=node/130&quicktabs_10=3>. Completed reviews of restoration practices applicable to the urban sector include:

- New State Stormwater Performance Standards,
- Urban Stormwater Retrofits,
- Urban Nutrient Management,
- Urban Stream Restoration,
- Enhanced Erosion and Sediment Controls, and
- Urban Filter Strip/Stream Buffer Upgrades.

Expert Panel reports essentially complete and awaiting approval include:

- Urban Shoreline Management, and
- Illicit Discharge Elimination (Nutrient Discharges from Grey Infrastructure).

Expert Panel reports in development include:

- Street Sweeping (including catch-basin clean outs and bulk sediment removal),
- Floating Wetlands,
- Urban Tree Planting/Expanded Tree Canopy, and
- Riparian Forest Buffers.

In addition to the changes in the pollutant removal efficiencies, the CBP is in the process of developing the next phase of the Watershed Model (Phase 6) to be used in the mid-point assessment to determine progress being made for the Chesapeake Bay TMDL. There will likely be changes in the land use categories designed to improve the model with respect to the pollutant loads associated with land use types. When the model is calibrated and run in 2017 there will likely be changes in the loads with respect to land use. This will necessitate a recalculation of the nutrient and sediment loads and the reductions associated with practices that treat the various land uses.

The document *Baltimore County Method for Pollutant Load Calculations, Pollutant Load Reduction Calculations, and Impervious Area Treated* will be posted for review and comment in the spring of 2015. It will be modified on an annual basis to take into account any future Expert Panel documents, modifications to any guidance documents and future calculations will reference the edition on which the calculations were based.

10.1.1 Reporting

Baltimore County will prepare two-year milestones for each local TMDL in conformance with the Chesapeake Bay TMDL two-year milestone process. Programmatic actions and monitoring data analysis will be based on the calendar year, while restoration actions will be based on the fiscal year (July 1 – June 30). The current two-year milestone period was developed in January 2014. These milestones include programmatic actions covering January 2014 through December 2015, and restoration actions for the July 1, 2013 through June 30, 2015 period. When the next two-year milestones are developed in 2016, they will be presented by watershed and will include each of the local TMDLs.

Reporting will be done through the annual NPDES – MS4 Permit Report. This is technically due on the anniversary date of the permit renewal, but will be completed for submittal to MDE in October each year. The report will detail progress made in meeting each of the local TMDLs and the Chesapeake Bay TMDL. The analysis will include progress in meeting the two-year milestone programmatic and restoration actions, along with the calculated load reduction. It will also present the results of the monitoring conducted the previous year. See below for TDML specific monitoring.

In January of each year, a progress report (mostly extracted from the MS4 report) will be prepared and posted on the web.

10.2 Implementation Progress: Water Quality Monitoring

The rationale for the development of the Loch Raven Reservoir Sediment TMDL is the reduction of the rate of infill of the reservoir to conserve the volume of water available for the current population served by the Baltimore City regional water supply system, and future population growth. While the current capacity of the reservoirs is adequate to serve the current population under normal rainfall years, the system has had to obtain water from the Susquehanna River during drought years, as recently as the early 2000s. As the regional population grows, the strain on the regional supplies will increase, particularly if drought again strikes the region. The loss of capacity reduces the ability of the water supply system to provide an adequate volume of water to sustain all water users.

Due to algal blooms in the 1970s in the three drinking water reservoirs serving the Baltimore metropolitan area, an initial Reservoir Watershed Agreement was signed in 1979 to address water quality issues within the reservoirs. The most recent agreement, Reservoir Watershed Management Agreement of 2005 called for continued and improved water-quality monitoring in the reservoirs and selected watershed tributaries. Coordination among the local jurisdictions and state agencies, and local soil conservation districts in meeting the Watershed Management Agreement provisions is provided by the Baltimore Metropolitan Council. In order to address the provisions of the agreement, the Baltimore Metropolitan Council has formed a Reservoir Technical Group (RTG), which in turn has developed the 2005 Action Strategy for the Reservoir Watersheds that details the actions necessary to meet the agreement requirements. One of the actions under *Reservoir and Watershed Assessment 1.1(3)* was a provision to evaluate the existing reservoir monitoring programs and develop a collaborative monitoring strategy for the reservoirs and their tributaries. In order to meet this action, in 2007, Baltimore City, Baltimore County, and Carroll County jointly funded an agreement with the U.S. Geological Survey (USGS) to assess the current monitoring programs and make recommendations for monitoring program improvements to meet a number of objectives, including, “to ensure that water quality in the three reservoirs and their tributaries consistently meet all applicable water quality standards established by Federal and State regulation”. The resulting publication The Water-Quality Monitoring Program for the Baltimore Reservoir System, 1981-2007 – Description, Review and Evaluation, and Framework Integration for Enhanced Monitoring (USGS 2011) provided an assessment of current monitoring programs and made recommendations for improvements. Since the publication of the report, a subcommittee of the RTG has assessed the information in the report and, based on the recommendations, has developed a monitoring framework. The next stage will be the hiring of a consultant to develop a Watershed Monitoring Plan document based on what has been developed to date. The Watershed Monitoring Plan will then be used as the basis for hiring a contractor to perform the sample collection, analysis, and data management. In accordance with the future Watershed Monitoring Plan, some of the following monitoring elements may be replaced.

10.2.1 Tributary Monitoring

There are two separate monitoring programs that assess chemical concentrations and loads within the Loch Raven tributaries: the Baltimore County Chemical Trend Monitoring Program (10.2.1.1), and the Baltimore City Reservoir Office Tributary Monitoring Program (10.2.1.2). Both are discussed below.

10.2.1.1 Baltimore County Chemical Trend Monitoring Program

The Baltimore County Chemical Trend Monitoring Program is conducted throughout the county. The program was initiated in 2010 and consists of a fixed-interval, fixed-site design with 40 sites countywide. Eleven of the sites are located within the Loch Raven Reservoir watershed. Monitoring will continue at these sites and will be used to assess the trend in TSS concentrations and loads over time (Figure 10.1).

10.2.1.2 Baltimore City Reservoir Office Tributary Monitoring Program

The Baltimore City Reservoir Office Tributary Monitoring Program collects samples from major tributaries to each of the reservoirs. Dry weather samples were collected from three major tributaries in the Loch Raven Reservoir watershed until 2013, when the sampling switched to a fixed- interval, fixed-site sampling program.

10.2.1.3 Future Tributary Monitoring Program

As indicated above, the tributary monitoring program is being modified based on the recommendations of the USGS. This future monitoring program will provide consistent monitoring data to allow an assessment of the progress being made in the reduction of sediment supply to the reservoir.

10.2.2 In-lake Bathymetric Monitoring

The end point for the Loch Raven Sediment TMDL is a 25% decrease in the rate of infill of the reservoir. In order to measure progress in meeting this TMDL, end point periodic bathymetric surveys need to be conducted. Baltimore City owns and manages the reservoir; therefore coordination with the city in developing a schedule of bathymetric surveys is required. Baltimore County will work with Baltimore City to determine an appropriate schedule of bathymetric surveys.

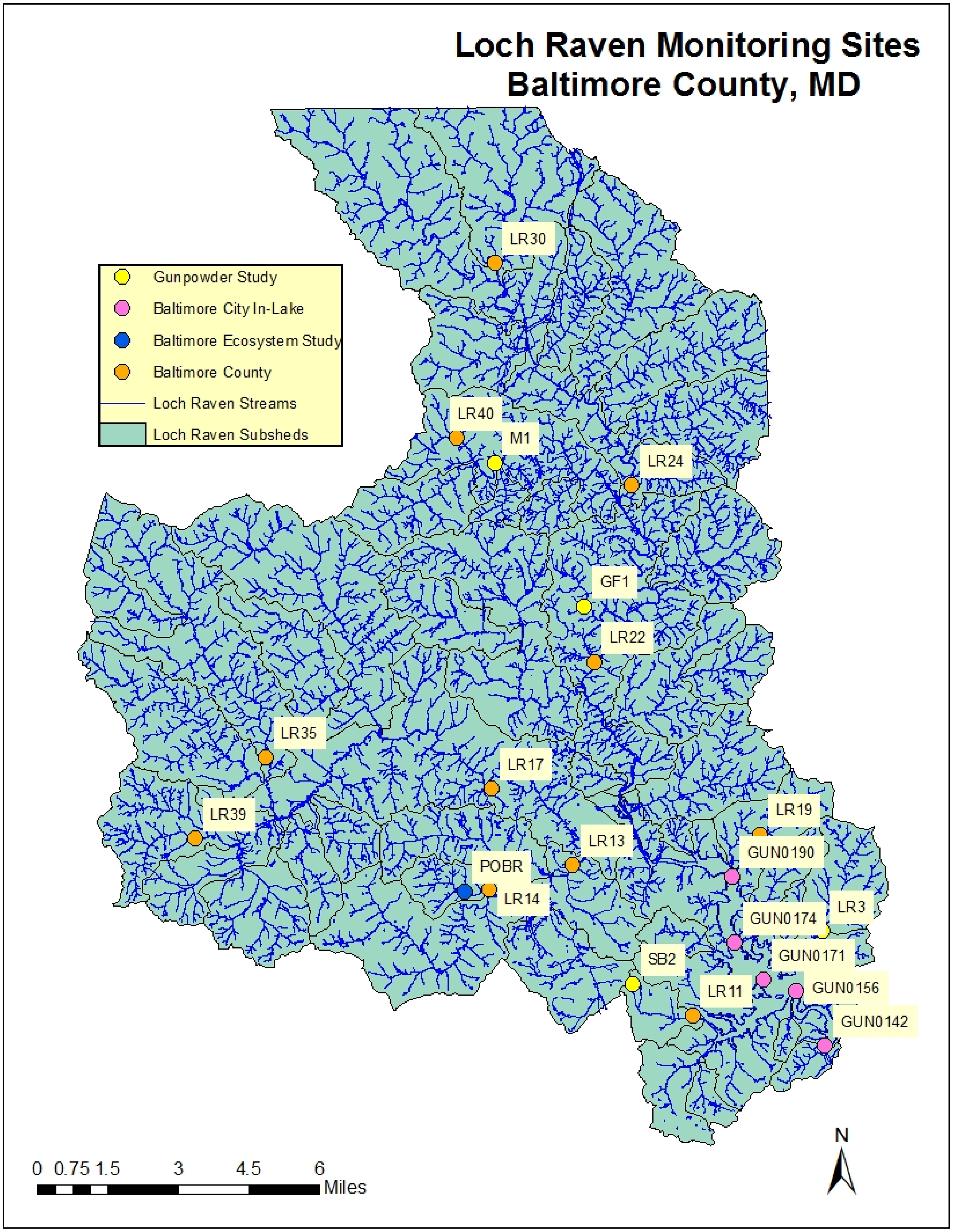

Figure 10.1: Sampling Locations Within the Baltimore County Portion of the Loch Raven Reservoir Watershed and Within the Lake.

Section 11 – Continuing Public Outreach Plan

In order to engage the public in the TMDL implementation process this continuing public outreach plan will be implemented upon approval of this TMDL Implementation Plan. The continuing public outreach plan is applicable to all TMDL Implementation Plans that are currently being developed and those developed in the future, as well as the Trash and Litter Reduction Strategy. This continuing public outreach plan is meant to engage county agencies, environmental groups, the business community, and the general public.

11.1 County Agencies

County agencies will be engaged through two regularly scheduled NPDES Management Committee meetings per year and other agencies meetings as necessary to move implementation forward.

11.1.1 NPDES Management Committee

The NPDES Management Committee is composed of representative agencies that are involved in meeting the NPDES – MS4 Permit requirements. This committee has met irregularly in the past, generally to review information on permit requirements and other upcoming regulatory requirements, such as, the General Industrial Stormwater Discharge Permit. In the future this committee will meet twice per year and will discuss not only the NPDES – MS4 Permit requirements, but also the TMDL Implementation Plans and progress being made in meeting the implementation strategy. In order to address all components of the TMDL Implementation Plans the committee membership will be expanded to include any county agency that has some responsibility for TMDL implementation. Examples being, the County Police Department and the Department of Environmental Protection and Sustainability – Groundwater Management Section. Prior to the development of the TMDL Implementation Plans and the Trash and Litter Reduction Strategy, these agencies were not specifically engaged in NPDES – MS4 Permit activities.

The first yearly meeting will be held in January of each year. The focus of this meeting will be to review the implementation plan 2-year milestones for each plan; provide a forum for discussion of the ability to meet the implementation actions; and determine any revisions necessary to meet the interim implementation milestones set in the plan. This meeting is also the forum for discussion of data tracking and reporting to ensure that the implementation actions are properly credited.

The second yearly meeting will be held in July of each year and will provide the forum for determining data submittal for the yearly progress report on the implementation actions and the resulting load reductions. The monitoring data from the previous calendar year will be presented and contrasted with the interim water quality milestones that are detailed in each implementation plan.

11.1.2 Other Agency Meetings

In order to move forward with implementation, agency meetings regarding specific implementation actions are anticipated. These will be scheduled as needed, and tracked by meeting date, attendance, TMDL Implementation Plans discussed, and topic. Meeting minutes will be reported in the Annual NPDES – MS4 Report submitted to Maryland Department of the Environment. This report is also posted on the County website for public access.

11.2 Environmental Groups

Baltimore County is currently engaged with local watershed associations through its funding of *Watershed Association Restoration Planning and Implementation Grants*, and through inclusion of watershed association members on the Steering Committees of the Small Watershed Action Plans. Formerly, this engagement and support was coordinated through the *Baltimore Watershed Agreement*. As part of that engagement, periodic Watershed Advisory Group (WAG) meetings were held. As part of this continuing public outreach plan, WAG participation will be formalized with two meetings per year.

The first meeting will be held in March of each year and focus on the local and Chesapeake Bay TMDL implementation actions and implementation progress, including an analysis of the pollutant load reduction calculations from the previous fiscal year. The watershed associations are currently engaged in citizen-based restoration activities and report their implementation progress to the county for inclusion in the Annual NPDES – MS4 Report. This meeting will provide a forum for discussion of the progress being made, coordination between the watershed associations, and any changes to the *Watershed Association Restoration Planning and Implementation Grant* being considered for the next grant period.

The second meeting will be held in November of each year and will focus on the water quality monitoring results from the previous calendar year. The results presented will compare trends and measures against the TMDL Implementation Plans water quality benchmarks and water quality standards.

11.3 Business Community

The business community will be engaged through various business forums, targeted outreach and education efforts on specific topics, and hosting workshops on specific topics as necessary.

11.3.1 Business Forums

Business forums, such as the Hunt Valley Business Forum with greater than 200 business members, provide opportunities to present the TMDL Implementation Plans and the Trash and Litter Reduction Strategy, and discuss the role of business in helping improve water quality. These forums will be convened as the opportunities arise. Summaries of these meetings will be reported in the annual NPDES – MS4 Report and will include the name of the forum (or other business organization), approximate number in attendance, the topic presented, and audience responses.

11.3.2 Targeted Business Outreach and Education

The Small Watershed Action Plan (SWAP) process includes an upland assessment of potential pollution hotspots. Often, these potential hotspots are commercial or industrial sites. The information derived from this assessment will be used to target outreach and education to businesses specific to the issue(s) at the location identified in each SWAP. These actions will be tracked and reported in the annual NPDES – MS4 Report.

11.3.3 Business Workshops

There are certain issues that may be pervasive through a segment of the business community that can most effectively be addressed through hosting workshop education on the specific topic. These issues will be identified as SWAP implementation moves forward, but one potential topic for a business workshop is related to the recently renewed *General Discharge Permit for*

Stormwater Associated with Industrial Activities. A workshop designed in conjunction with Maryland Department of the Environment would not only result in improved water quality, but it would also benefit the business community through increased understanding of the requirements of the permit.

11.4 General Public

The general public will be engaged through a number of mechanisms, including:

- WIP Team meetings
- Targeted outreach and education efforts on specific topics
- Steering Committee meetings and stakeholder meetings in the development of Small Watershed Action Plans
- Meetings of the Implementation Committee for completed Small Watershed Action Plans
- Displays at various events
- Annual progress reports posted on the county website and placed in our libraries
- A biennial *State of Our Watersheds* conference.

11.4.1 Watershed Implementation Plan (WIP) Team Meetings

Baltimore County has assembled a Watershed Implementation Plan (WIP) team to serve as a sounding board for the development of the WIP to address the Chesapeake Bay TMDL. Members of the team include representatives from various county agencies, business community representatives (particularly the environmental engineering community), watershed associations, representatives from the agricultural community, and Baltimore County citizens.

The county will schedule at least one meeting annually to present implementation progress and to address specific topics related to the TMDL Implementation Plans and the Trash and Litter Reduction Strategy. Meetings will be scheduled as issues arise. It is anticipated that the WIP team will provide initial review of newly developed outreach and education materials, in order to provide feedback from a variety of perspectives.

11.4.2 Targeted Outreach and Education

The Small Watershed Action Plan development process includes upland assessments of neighborhoods to identify pollution sources and restoration opportunities. This information will be used to prioritize and target outreach and education efforts specific to the issue(s) in neighborhoods with the intent to affect behavioral change and/or increase citizen based restoration actions. These actions will be tracked and reported in the annual NPDES – MS4 Report.

11.4.3 Small Watershed Action Plans (SWAPs)

Baltimore County has been developing Small Watershed Action Plans since 2008. There are 22 planning areas in the county, with 13 completed plans, 5 plans in development, and 4 areas pending. These planning areas cover the entire county. The planning process includes the development of a steering committee, the composition of which is determined by the issues, and land ownership within the planning area. At a minimum, membership consists of agency representatives, watershed associations, and citizen representatives. The process also includes a number of stakeholder meetings, open to all planning area residents and businesses, which provide information on the plan and solicit input. Once the SWAP is complete, the steering committee becomes the implementation committee. As designed the implementation committee is to meet twice per year, however, most implementation committees have not met this goal.

The plans have addressed to varying degrees the TMDLs that are applicable within the planning area. Some of the TMDLs have been developed subsequent to the specific SWAP development or did not address the full range of TMDLs that were applicable to the planning area. The TMDL Implementation Plans are built on incorporation of the actions from each SWAP within the applicable TMDL area. In some cases, additional actions have been identified in order to meet water quality standards.

11.4.3.1 Small Watershed Action Plans in Development and Future Plans

For SWAPs currently under development, and for plans developed in the future, the steering committee and stakeholder meetings will be used for outreach regarding the TMDL Implementation Plans and the progress being made in achieving water quality standards. The meeting participants will be informed on where they can access the TMDL Implementation Plans, the Trash and Litter Reduction Strategy and any Progress Reports that have been developed.

Applicable TMDL Implementation Plan actions will be incorporated into the SWAP based on the assessment of applicable restoration actions within the SWAP planning area. Since the SWAPs incorporate field assessments of streams and uplands, they provide more detailed information on applicable restoration actions, both on quantity and location. The accelerated schedule for developing TMDL Implementation Plans precluded conducting field work to build the plans.

11.4.3.2 Small Watershed Action Plans Already Developed

For those SWAPs already developed, the implementation committee meetings will be scheduled twice per year. The first meeting will be held in winter and will present the implementation progress not only of the SWAP, but also any applicable TMDL Implementation Plan progress. The progress analysis will be based on fiscal year. This meeting will also provide the opportunity to discuss any changes in the SWAP or the TMDL Implementation Plan based on an analysis of what actions have been successful and what actions have been more difficult to implement.

The second implementation committee meeting will be held in fall of each year and will present the monitoring data in relation to progress being made in relation to interim milestones and water quality standards.

11.4.4 Educational Displays at Events

Educational displays and handouts will continue to be used at applicable events as they occur. The particular display and handout materials will be determined by the location and focus of the event. The location and focus of the event, number of citizens engaging staff at the display, and the number of handouts taken by citizens will be tracked for annual reporting in the NPDES – MS4 Report.

11.4.5 TMDL Implementation Plan, Trash and Litter Reduction Strategy, and Progress Report Availability

The TMDL Implementation Plans and the Trash and Litter Reduction Strategy will be posted on the Baltimore County website with hard copies placed in county libraries. The hard copies in the libraries will be specific to the watershed in which the library is located. Progress reports will be posted on the County website and placed in libraries. A set of hard copy plans will be kept at the Baltimore County Department of Environmental Protection and Sustainability

11.4.6 Biennial State of Our Watersheds Conference

Baltimore County, in conjunction with Baltimore City, has held *State of Our Watershed* conferences in the past to present information to county and city citizens on water quality issues applicable to the watersheds in these jurisdictions. Future conferences will be held in early March of even numbered years. Information on implementation progress for local TMDLs and the Bay TMDL will be presented, along with other topics of interest. These conferences will be organized with the assistance of the Watershed Advisory Group (WAG), and the surrounding local jurisdictions (Baltimore City, Howard County, Carroll County, Harford County, and York County, PA) will be invited to participate in the organization and presentation of the conference.

The timing of even years is related to the 2-year milestone process set up by the Maryland Chesapeake Bay TMDL Watershed Implementation Plan (WIP) whereby in January of even calendar years, progress in meeting the previous 2-year milestone programmatic and restoration implementation is reported and the next 2-year programmatic and restoration implementation milestones are proposed by the local jurisdictions. The timing of the conference not only permits reporting on the progress made in meeting the previous 2-year milestones but also what is planned for the next two years.

11.5 Summary of Continuing Public Outreach Plan

A summary of the continuing public outreach plan, by component, element and frequency is presented in Table 11.1.

Table 11.1: Continuing Public Outreach Plan Summary

Plan Component	Plan Element	Frequency
Agencies	NPDES Management Committee	2x per year
	Other Agency meetings	As needed
Environmental Groups	Watershed Advisory Group (WAG) meetings	2x per year
Business Community	Business Forums	As identified
	Targeted Business Outreach and Education	As identified
	Topical Workshop	As identified
General Public	WIP Team meetings	1x per year
	Targeted Outreach and Education	As identified
	SWAP – Steering Committee meetings	6x per year, each
	SWAP – Stakeholder meetings	2x per year, each
	SWAP – Implementation Committee meetings	2x per year, each
	Educational Displays at Events	As identified
	Document availability (various)	As needed
	Biennial Conference	Even # Years

Berry, Walter, Norman Rubinstien, and Brian Melzian. *The Biological Effects of Suspended and Bedded Sediment (SABS) in Aquatic Systems:A Re.* Internal Report, Narragansett: US Environmental Protection Agency Office of Research and Development , 2003.

Booth, Derek B., and Patricia C Henshaw. "Rates of Channel Erosion in Small Urban Streams." *Stream Channels in Disturbed Environments: AGU Monograph Series*, 2000.

Colorado Department of Public Health and the Environment Water Quality Control Commission Water Quality Control Division. *Implementation Guidance for Determining Sediment Deposition Impacts to Aquatic Life in Streams and Rivers.* Denver, CO: Colorado Department of Public Health and the Environment, 2005.

Davis, Lisa. "SEDIMENT ENTRAINMENT POTENTIAL IN MODIFIED ALLUVIALSTREAMS: IMPLICATIONS FOR RE-MOBILIZATION OF STOREDIN-CHANNEL SEDIMENT." *Physical Geography* (Department of Geography University of Alabama), 2009: 30, 3, pp. 249–268.

Department of the Environment. "Sedimentation in Storage Reservoirs." Transport and the Regions, Halcrow Water, Wittshire, 2001.

EPS, B. C. (2012). *Lower Patapsco Small Watershed Action Plan.*

Graf, William L., Ellen Wohl, Tushar Sinha, and John L Sabo. "Sedimentation and Sustainability of western American reservoirs." *Water Resources Research* 46, no. W12535 (2010).

Jin, S. Y. (2013). . *A comprehensive change detection method for updating the National Land Cover Database to circa 2011. Remote Sensing of Environment.*

Lester, Liza. "A Yellow Perch in Murky Water." *Ecological Society of America.* January 11, 2013. http://www.esa.org/esablog/research/a-yellow-perch-in-murky-water/ (accessed March 1, 2014).

Lisle, Thomas E. *Sediment Transportation and Resulting Deposition in Spawning Gravels, North Costal California* . Arcata, CA: Pacific Southwest Experiment Station, Forest Service, U.S. Department of Agriculture, 1989.

Maryland Department of the Environment. (2006). *Total Maximum Daily Loads of Phosphorus and Sediments for Loch Raven Reservoir and Total Maximum Daily Loads of Phosphorus for Prettyboy Reservoir, Baltimore, Carroll and Harfotd Counties, Maryland.* Baltimore, MD: Maryland Department of the Environment.

Maryland Department of the Environment. *Total Maximum Daily Load of Sediment in the Patapsco River Lower North Branch Watershed, Baltimore City and Baltimore, Howard,* *Carroll and Anne Arundel Counties, Maryland.* Baltimore, MD: Maryland Department of the Environment, 2011.

MDE. (2011). *Point Source Technical Memorandum.*

MDE. (2014). *MDE TMDL Data Center WLA Search*. Retrieved from MDE: http://wlat.mde.state.md.us/WLASearch.aspx

MGS. (2009). *Guide to Maryland Geology (updated January 22)*. Retrieved from MGS Online: http://www.mgs.md.gov/indexgeo.html

Nelson, Erin J., and Derek B. Booth. "Sediment sources in an urbanizing, mixed land-use watershed." *Journal of Hydrology*, 2002: 51-68.

U.S. Department of the Interior. (2009). *Adaptive Management: The U.S. Department of the Interior Technical Guide.* Washington. Retrieved 2014, from U.S. Department of the Interior: http://www.doi.gov/ppa/upload/TechGuide-WebOptimized-2.pdf

U.S. Geological Survey and U.S Department of the Interior. *A Summary Report of Sediment Processes in the Chesapeake Bay Watershed.* New Cumberland, PA: U.S. Geological Survey, 2003.

USDA. (1986). *Technincal Release 55: Urban Hydrology for Small Watersheds.* Washington, DC: Natural Resource Conservation Service, Conservation Engineering Division.

Utah Division of Water Resources. "Managing Sediment in Utah's Reservoirs." State Plan, 2010.